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What is on the Other Side of the Tracks? A Spatial Examination of Neighborhood Boundaries and Segregation

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Abstract

Space has always been a critical component of the sociological study of racial inequality, yet it has rarely been the central focus of empirical projects. Studies of segregation, an inherently spatial concept, have relied on techniques that are aspatial introduce an unknown amount of error into their results. This project extends standard spatial analytic techniques to the sociological study of racial segregation, using Philadelphia as its case study. By introducing non-euclidean kernel density analysis to the study of racial segregation, the project explores how a more visual and more spatially informed approach changes the geography of racial segregation. A more visual approach to segregation more readily identifies locations of racial turnover compared to traditional measures such as indices dissimilarity, entropy, and isolation. Incorporating physical barriers into a spatial measure of segregation also complicates the finding that segregation is decreasing over time at a substantial rate and is able to identify and locate specific areas within the city where segregation is uniquely persistent or uniquely transitory, and that racial boundaries such as major roads or railroad tracks are more strongly associated with protecting white neighborhoods from non-white residents rather than isolating black or Hispanic populations. A spatial sociology of inequality offers a novel lens through which to study racial inequality, segregation, and make those findings relevant to efforts to lessen segregation's impact on inequality.

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WHAT IS ON THE OTHER SIDE OF THE TRACKS? A SPATIAL EXAMINATION OF
NEIGHBORHOOD BOUNDARIES AND SEGREGATION

Rory Kramer

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in

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Presented to the Faculties of the University of Pennsylvania

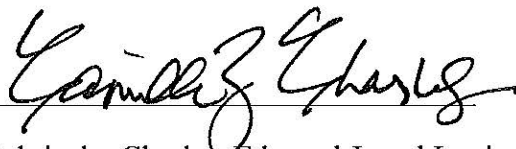
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WHAT IS ON THE OTHER SIDE OF THE TRACKS? A SPATIAL EXAMINATION
OF NEIGHBORHOOD BOUNDARIES AND SEGREGATION

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Rory Alexander Kramer

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To the city of Brotherly Love and the people I've met here

ACKNOWLEDGMENT

This dissertation began with a flippant thought as I walked to the subway one day to get to a meeting on campus. Two blocks from my apartment on a block experiencing rapid gentrification—bring with it both the benefits of a gastropub on the corner and the problems of a seemingly inevitable racial turnover—lies Broad Street. Across Broad Street is an equally centrally located neighborhood, but instead of similar signs of revitalization and investment, beautiful residential architecture from the turn of the century was visibly being left to deteriorate. One street was all that prevented that gentrification from spreading. Trying to understand how that sharp divide was created and continues became the germ of an idea that grew into this dissertation.

Less abstractly and more personally, while a dissertation is an academic's first individual research project, it is also the first time an academic realizes no work is truly individual. While the mistakes and blind spots in this project remain mine and mine alone, any insights are thanks to a large group of people who supported, challenged, pushed and prodded me. First, I have to thank Camille Charles, my advisor, mentor, chair, friend, spades rival, and role model. Camille's exacting need to get the model just right while also making sure the project speaks clearly to a wider audience is a balance I hope to achieve myself. Similarly, her ability to be a world class scholar and world class mentor to undergraduate and graduate students is what I hope to become. Grace Kao's guidance and advice from day one of my graduate school tenure has helped shape me as a scholar and as a member of a department. Tara Jackson's insistence that my work is an

important addition to the sociology of space and race has been a constant source of energy and a constant reminder to make sure I “get” space better. I hope I have. Finally, Keith Reeves has been a source of support, enthusiasm, and tough questions that make sure I don’t lose myself in the minutiae of kernel density smoothing techniques and to return to the original reason I began to study racial boundaries—to better understand and possibly help mitigate racial inequality.

Outside of my committee, many more people at Penn were crucial to my success. Dana Tomlin’s role as GIS Santa Claus cannot be understated. His class was a key moment in recognizing the potential of spatial analysis to radically change the study of racial segregation. Since then, it is his python script that enabled my specific spatial analysis and conversations with him that refined my understanding of how to incorporate space into sociological fields while describing them in ways social scientists and laypeople might possibly understand. I smush and spread in his honor. Thanks also to Vicky Tam, whose help was vital to my not giving up on GIS in frustration within a few months of starting down this path. To the Center for Africana Studies for their daily support, free coffee, interest, and positive attitude. Before I found a home in CFAS, coming to campus was a disheartening part of my day—heading in to CFAS, however, became heading to a second home, thanks to Carol, Gale, Sean, Michelle and Barbara, as well as the general awesomeness of “the corner” and its rotating cast of characters.

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Rebecca, Simon, Lauren, Jon, Teague, Alex, Marin, and many more I may have forgotten. Of course, thanks to my family, from my mom's undying support to my brother's friendly trash-talk and Renee's chiding to my dad's interest in entropy "as a physics concept," it was my family that led me down the path to care about inequality and believe I might be smart enough to say and do something about it.

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ABSTRACT

WHAT IS ON THE OTHER SIDE OF THE TRACKS? A SPATIAL EXAMINATION OF NEIGHBORHOOD BOUNDARIES AND SEGREGATION

Rory Kramer

Camille Charles

Space has always been a critical component of the sociological study of racial inequality, yet it has rarely been the central focus of empirical projects. Studies of segregation, an inherently spatial concept, have relied on techniques that are aspatial introduce an unknown amount of error into their results. This project extends standard spatial analytic techniques to the sociological study of racial segregation, using Philadelphia as its case study. By introducing non-euclidean kernel density analysis to the study of racial segregation, the project explores how a more visual and more spatially informed approach changes the geography of racial segregation. A more visual approach to segregation more readily identify locations of racial turnover compared to traditional measures such as indices dissimilarity, entropy, and isolation. Incorporating physical barriers into a spatial measure of segregation also complicates the finding that segregation is decreasing over time at a substantial rate and is able to identify and locate specific areas within the city where segregation is uniquely persistent or uniquely transitory, and that racial boundaries such as major roads or railroad tracks are more strongly associated with protecting white neighborhoods from non-white residents rather than isolating black or Hispanic populations. A spatial sociology of inequality offers a novel lens through which to study racial inequality, segregation, and make those findings relevant to efforts to lessen segregation's impact on inequality.

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Chapter 1:

Space and Segregation in Sociology

Had sociology been born in a more racially just society, urban sociologists might refer to the Du Boisian school of study as a parallel foundational orientation to the Chicago School, or even more radically, its main foundation thanks to Du Bois' seminal *The Philadelphia Negro* (1996 [1899]). Instead, it is something of a cliché to begin a study of segregation with Du Bois' comment that the story of the 20th century is that of the color line. Far too often, Du Bois' impact is left at that level—an approving nod to his way with words, particularly those found in *The Souls of Black Folk*. Du Bois' community study, a template upon which the Chicago School greatly rested, was the first social study to expose two now common-sense findings: that the community context in which an individual lives has a substantial impact on that individual's outcomes and that segregation is a critical mechanism for creating and perpetuating racial inequality in the United States.

While Du Bois' seventh ward is now divided into three wards and crosses at least three different neighborhoods that are disproportionately white and wealthy (with a small enclave of remaining working class black residents), Philadelphia continues to be a rich location to study residential segregation and neighborhoods. The city prides itself as being a “city of neighborhoods,” many of which have had stable boundaries and strong

identities across generations¹. The former seventh ward—from Spruce Street to the north to South Street to the south, and from 7th street on the east to the Schuylkill River to the west—is a prime example of both the stability and change in Philadelphia’s self-image. Over one hundred years ago, the seventh ward was a definable neighborhood and base of Philadelphia’s black population. Today, some of those boundaries persist; South Street continues to divide wealthier neighborhoods to its north (Rittenhouse Square, Fitler Square) from previously poor, now gentrifying neighborhoods to the south (Southwest Schuylkill/Graduate Hospital), but Spruce Street is no longer seen as a meaningful boundary between neighborhoods. Similarly, while Seventh Street was a useful boundary for Du Bois, today Seventh Street does not serve as a boundary but the Schuylkill River continues to divide West Philadelphia from Center City.

Philadelphia’s neighborhood names and regions have strong meaning to its residents. Fishtown, while currently famous as Charles Murray’s ideal type white working class neighborhood (although, ironically, now undergoing substantial gentrification), has long been locally notorious for its uniquely strong accent and white immigrant identity. The Northeastern part of Philadelphia, divided into dozens of separate neighborhoods, is often derided by residents of other parts of Philly as “the Greater Norfeast” due to its homogeneously white and mostly lower middle class residents. Similarly, North Philly as a region conjures up images of the most devastated

¹ In fact, Philadelphia’s Department of Records includes a list of neighborhood names, both current and historical on its website at: <http://www.phila.gov/phils/docs/otherinfo/pname1.htm>

neighborhoods with high vacancy rates and crime patterns. Kensington is a name that provides great pride for many residents and contains the Barrio de Oro as a proud enclave of ethnic identity (Wherry 2011), and also great consternation as it is also known for its open air drug markets and prostitution. Whether one says they are from South Philly or a specific neighborhood in South Philly helps identify the newcomers, to whom specific neighborhoods have been marketed and branded, from the multigenerational residents who see anywhere south of South Street as part of a larger region and shared identity.

The strong local debates over neighborhood names highlight the importance of social boundaries in constructing a sense of identity and imagined community (Anderson 1991) in the anonymous city (Wirth 1938). The area sandwiched between Chinatown to the south, Poplar to the north, and between Broad Street to the west and 8th or 9th street to the east is a useful example of those battles. The area, previously a largely depressed former industrial center became known to many residents as Eraserhead in the 1980s, due to its reputation as a drug haven that was the inspiration for David Lynch's 1977 surrealist cult hit of the same name. More recently, as some of those former industrial spaces have been repurposed as art galleries and loft apartments, real estate agents have rebranded it "The Loft District" and highlight its proximity to public transportation, the center city business area, and low housing prices. At the same time, because Chinatown is one of the most densely built and populated areas in Philadelphia and has seen its borders potentially encroached on by the building and expansion of the Convention Center and various "redevelopment" efforts that have failed in the past decades (a center

city stadium and large casino were both proposed for the area)², many Chinese immigrant owned businesses have opened or relocated themselves in the area. To them, the area is “North Chinatown.” A third group, many of the artist residents and other gentrifiers, many of whom have lived in the area for over a decade, have taken to calling the area Callowhill after the major road that runs through it.

The area is also home to over a mile of unused elevated railroad tracks, the Reading Viaduct (hence yet another nickname for the area that has fallen out of favor: Trestletown), that many residents hope to turn into Philadelphia’s version of New York’s famed High Line Park to help spur more development and improve the area’s image while attracting tourists. Recently, the city council proposed creating a neighborhood improvement zone, a vehicle for imposing an additional tax on landowners to fund infrastructure and cleaning in the area as a next step in building the Reading Viaduct Park. The effort, supported by many local residents as well as major political figures in the city, was defeated thanks to the efforts of local business owners led by a married pair of Asian immigrants, one a Chinese engineer, the other a Korean police officer. The battle over whether the area will become an arts and parks hub of the city or relieve Chinatown of its density continues. Regardless of which side eventually succeeds, it should come as no surprise that such battles over land use occur in areas with many

² Chinatown’s borders are clear: to the west, Chinatown is bordered by Reading Terminal Market, Philadelphia’s bus terminal, and the Convention Center. To the East, Franklin Square Park and local and federal government buildings constrain any growth, while Market Street and I-676 barricade any expansion to the south and north respectively.

disparate names. Simultaneously in South Philadelphia, the black residents of Point Breeze are battling efforts to develop new, higher priced housing stock and related business development. The white business owners and developers interested in gentrifying parts of Point Breeze have begun to refer to the area as “Newbold” to differentiate themselves from the rest of the area. Recent zoning meetings in the area have required police presences, and led to accusations of racism, cronyism and political impropriety (Briggs 2011; Melamed 2012).

In both of the above cases, the physical boundaries surrounding neighborhoods are a critical part of the story. In North Chinatown/Callowhill, interstate 676’s large physical imprint is the principle reason why that area has recently become a new immigrant destination and has remained underdeveloped since industry left. The existence of a major highway—below ground level, but not a tunnel—long influenced Chinatown’s growth pattern to emphasize density over spreading outward; crossing the two service streets and bridge between them that runs over the expressway created clear boundaries between Chinatown and the area above it. At the same time, the area north of Chinatown saw little development because it was not in the politically defined Center City and thus was not part of the major redevelopment push undertaken during Ed Rendell’s term as mayor, and because that highway created a social and spatial barrier that led to its underdevelopment and the current struggle to define its future.

In Point Breeze/Newbold, the problem of physical geography is reversed: there is no major boundary street that protects Newbold. Once gentrification and racial turnover

began to reach south of Washington Avenue, a large four lane road lined with major warehouses and box stores, there were no major landmarks or streets to stop developers in search of areas with cheap land and decent access to center city. As such, while Point Breeze long had been neglected by developers, it became an ideal next site for gentrification due to its location near subway stops, the newly expensive Graduate Hospital area, and the revived commercial strip of East Passyunk Avenue. As such, gentrification has spread quickly over the past ten years from Center City to the south, and areas of Point Breeze are now struggling with rebranding and to be redeveloped.

Social scientists have a long history of studying redevelopment, residential segregation and racial turnover. In particular, studies of residential segregation proffered Schelling's mathematical model that prove why racial integration is more often than not a transient state in the process of turnover (Schelling 1971; 1972; Friedman 2008; Charles 2003; Clark 1991). While the original model was interested in white flight and black invasion-succession (Schelling 1971; 1972), its insight into the difficulties inherent in supporting integration extend to the multiracial city of today (Charles 2006). While Schelling's insight into the impact of racial preferences on residential segregation has helped explain the relative rarity of integrated neighborhoods, it did so with a cost. By abstracting from the lived experiences of residents to a mathematical model of racial invasion-succession, the model does not consider space an important variable for understanding the extent of residential racial segregation (for more recent considerations of that same aspatial modeling see Bruch and Mare 2007; for examples that begin to consider the impact of space, see South and Crowder 2007; Sharkey 2009). This

exemplifies a trend within sociology: while previous social scientists and theorists discussed the impact of boundaries and physical space on these processes (see Hunter, 1972; Jacobs 1961), as sociology's methods grew more mathematically rigorous, they also grew less and less spatially aware. This project is an effort to bring boundaries and spatial analysis back into the study of residential segregation as a fundamental part of understanding and measuring levels and patterns of segregation.

Du Bois' *Philadelphia Negro* begins with a map of the seventh ward. One of the most impressive (albeit problematic due to its Victorian presumptions) parts of the book may be his later map of where the black residents of the seventh ward lived and their "class." Most sociological studies of segregation, however, do not map their results. Partly, that is because traditional measures of segregation such as the index of dissimilarity cannot be mapped. However, more recent work based in spatial analysis (Lee, Reardon, Firebaugh, Farrell, Matthews, O'Sullivan 2008) also privileges the traditional table and graph over the map, even as they offer some maps as illustrative examples. While this may be easier to read for quantitative academics, maps provide two benefits that have been largely ignored in sociology even as the advent of GIS technology has made mapmaking significantly easier as part of social science research. First, maps allow researchers to study local patterns of segregation, where and how it spreads across time *and* space, where it *does not* spread, and what might explain those spatial patterns. Such insights may be particularly relevant to policy makers who can then target policy initiatives to specific sections of cities that are ripe for integration—or perilously close to re-segregating or racial turnover. Second, a map can be a powerful and more easily

interpreted presentation of results for non-academics. While there has been some mainstream press interest in results from reports on changes in the index of dissimilarity, a set of online maps of racial segregation published online by an amateur cartographer named Eric Fischer quickly became an internet sensation and major news outlets such as *The Washington Post*, *San Francisco Chronicle*, *Time* and England's *Daily Mail* covered it, while the *New York Times* recreated similar maps with more recent data than Fischer. This project follows that example and uses mapping technologies to present data on the locations and patterns of racial segregation in the hopes of making the results of a mathematically complex method more accessible to non-quantitative scholars, policy makers, and lay people. Studies of racial inequality have a special duty to not only accurately measure the persistence and structural roots of racial inequality, but to present them to the public in the hopes of helping to alleviate that stain on society.

Residential Segregation and Sociology: A Renewed Interest

Unfortunately, Du Bois' work went largely ignored for decades as sociologists studied the city either without studying the racial inequality of the city or simply interpreting that racial segregation and inequality as natural or simply a stage in an ecological process with rare exceptions like Drake and Cayton's classic study of Chicago's South Side (1945[1993]). Sociological work in the 1960s through parts of the 1980s rarely focused on residential segregation, viewing it as in decline or as an issue of individual preference because the Fair Housing Act had been passed, even though later

scholars such as Meyer (2000) and Yinger (1995) highlight the persistence of racial discrimination in housing. Discriminatory practices persisted well after the FHA was passed, but segregation was treated either as a secondary component of the larger problems of racial inequality, or a methodological puzzle (Lieberson 1981; white 1983; Massey and Denton 1988; for an exception, see Taueber and Taueber 1965). Two efforts reinvigorated the sociological study of segregation and racial inequality: William Julius Wilson's *The Truly Disadvantaged* (1987) and Massey and Denton's *American Apartheid* (1993). Wilson argued that the residential isolation of impoverished black communities that was due to the increased spatial mobility of middle class black families led to a concentration of social problems into a few urban neighborhoods unlike previous generations. Massey and Denton argued instead that increased black residential mobility was related but not causal to the problems of the urban black poor. Instead, white segregation was to blame: because whites separated themselves from all black residents, they concentrated poverty in black neighborhoods with or without black middle class mobility. Some empirical evidence exists to support both theories (Quillian 1999), but the majority of empirical research supports Massey and Denton's argument that residential segregation is fundamental to understanding the persistence and strength of phenotypically black disadvantages (Rugh and Massey 2010; Fong 1994; Logan and Alba 1995; Jargowsky 1996; Charles 2003). Further, while black families with higher socioeconomic statuses do live in less segregated areas, black-white segregation remains high regardless of socioeconomic status (Adelman 2004; Darden and Kamel 2000; St John and Clymer 2000), and many black middle class neighborhoods are

disproportionately geographically and socially connected to neighborhoods with concentrated poverty (Patillo-McCoy 1999; Peterson and Krivo 2010).

Research on segregation returned to the public eye with the release of the 2010 census data. At the same time that the increasing spread and diversity of immigrants to new destination cities and suburbs has helped racial segregation continue to fall, income segregation has risen dramatically (Reardon and Bischoff 2011; Iceland 2009; Logan and Zhang 2010). In particular, the small decreases in segregation overall and continued growth of Latino and Asian populations has allowed some conservative thinkers and scholars to proclaim the “end of the segregated century” (Glaeser and Vigdor 2012) and receive substantial mainstream press coverage³. More careful analyses show that racial

³ It is hard to identify every methodological flaw or questionable analysis in that report. Two examples should suffice. First, Black/White segregation in highly multiracial substantially obscured by the report’s focus on Black/non-Black segregation. New York’s dissimilarity index in 2010 is 64.7 according to Glaeser and Vigdor—which would still qualify as hypersegregation. However, New York’s Black/White segregation is 79.1 and fell half as quickly as Glaeser and Vigdor’s less rigorous definition of segregation between 2000 and 2010. Second, Glaeser and Vigdor highlight the fact that there are only 424 census tracts with a population of at least 1000 residents without a single Black resident in them. This is indeed an improvement from the 1960s and 1970s. However, 10,719 tracts of the 71753 (roughly one in seven across the country!) are 99% non-Black. Another 25,299 are 95% non-Black. On the other end of the spectrum, 6446 tracts are over 50% Black (Black residents make up 13.6% of the population in the country). Almost 2000 tracts are > 90% Black and another 1000 are between 80 and 90% black. This does not seem like the end of segregation, but rather weakening from extremely entrenched to slightly-less-than-extremely-entrenched.

segregation, particularly black/white segregation, actually continues to be high and durable in cities with long histories of black population and segregation (Logan 2011; Logan and Stults 2011; Logan and Zhang 2011).

Where one lives is a major decision that has long ranging consequences for one's social network, education, employment, and social status. As such, racial residential segregation is a critical impediment for equality. Sociologists have highlighted the impact of segregation on educational outcomes, crime victimization, wealth accumulation, employment opportunities, access to social services and government, and social capital (Charles 2003; 2006; Leventhal and Brooks-Gunn 2000; Morenoff 2003; Sampson, Sharkey and Raudenbush 2008; Wodtke, Harding and Elwert 2011). Segregation matters and now is a highly studied topic in sociology⁴.

Wilson argued that the leading cause of concentrated urban poverty was that deindustrialization left the urban working class bereft of opportunity, starting in the 1960s and 1970s. At the same time, more black Americans got access to improved education, middle class careers, and new neighborhoods outside of the urban center. Therefore, with their newfound residential mobility, the black middle class followed the white middle class out of the city, leaving the urban centers two concurrent problems: a

⁴ Charles's 2003 review of the topic has been cited over 170 times on web of science and 343 times according to google scholar. In both cases, that is the most citations for the 2003 volume of ARS and just misses being included in the list of 20 most cited articles from ARS due to its relative recency (no article from after 2002 is in the top 20, and only 3 articles from 2002-2011 have been cited more often)

loss of its tax base and a loss of job opportunities. The American urban crises of the 1980s and the extreme concentration of disadvantage in black urban neighborhoods, he argues, were born of that mix. Massey and Denton assert that while housing laws ostensibly opened up new residential markets to non-white Americans, the reality is that the combination of racial inequality and continued discrimination led to much less mobility than hoped. Black Americans, even those who moved out of the “ghetto,” still experienced high levels of segregation that led to higher levels of local poverty, joblessness, and the subsequent disadvantages that come with those realities. One can categorize these two arguments as representing the two main theoretical orientations for explaining the persistence of racial segregation. Wilson’s argument that black middle class residents had gained access to spatial mobility that then led to the concentration of disadvantage in poorer black communities is an early form of the spatial assimilation model. On the other hand, Massey and Denton’s argument that continued discrimination and structural inequality continue to restrict black access to integration is an early example of the place stratification model.

Evidence from ethnographic work (Patillo-McCoy 1999) shows that black middle class residents are able to move out of impoverished neighborhoods, as the spatial assimilation model would predict. However, these residents were not moving far from the concentrated disadvantage (Peterson and Krivo 2010) and lived in comparably worse neighborhoods than white individuals from similar class backgrounds, although that difference has shrunk somewhat (Adelman 2004). The inclusion of wealth as a factor in segregation complicates the issue further: the black-white wealth gap is substantially

larger than the income gap (Oliver and Shapiro 1997), thus implicating any study that looks at education or income as a proxy for socioeconomic class as biased by not including wealth in its analyses. The wealth gap is also more complicated: most families' wealth is largely invested in their homes, particularly non-white wealth; in 2005 housing equity represented roughly 60% of black wealth while it only represented 44% of white wealth (Kochlar, Fry, and Taylor 2011). As such, black families both have worse access to wealth that can be translated into spatial assimilation *and* the lack of capital is perpetuated by the continued stigmatization and lowered housing values that are associated with living in a black neighborhood. This also means that black (and Hispanic) households experienced the sharpest decline in wealth during the housing recession of the late 2000s: while average white household wealth dropped from \$135,000 to \$113,000 between 2005 and 2009, black households lost over half of their wealth, from just over \$12,000 to under \$6000 in the same period.

Trends in Segregation

Black-White segregation is one of the most persistent inequalities in American society. Although some argue that segregation peaked in the 1960s or 1970s (Logan and Stults 2011), trends in the hypersegregation of black residents actually appear to have

peaked in the 1990s when 29 major metropolitan areas qualified as hypersegregated⁵ and either slightly weakened or stayed consistent through 2000 (Wilkes and Iceland 2004)⁶. Also dispiriting is the fact that the 2000 decennial census was also the first to expose hypersegregation for Hispanics in two metropolitan areas as well. By the 2010 decennial census, segregation continued to fall; though the pace continues to be extremely slow, some optimism may be warranted as segregation did fall in many Northeastern and Midwestern areas that previously had both very high and very stable levels of segregation in the late 20th century (Logan and Stults 2011).

Two other trends in racial segregation since the 1960s are also relevant to this study. First, the 1965 changes in immigration law have led to large gains in the relative and actual size of the Hispanic and Asian populations, particularly since 1980. The Census Bureau received national attention when, in 2008, it predicted that the non-Hispanic white population would be a numerical minority in the country by 2042, and a minority of the child population by 2023. Less than three years later, upon release of the 2010 census data, those projections may already be dated, as the continued large growth in the Hispanic population and other minority populations mean that the child population

⁵ Hypersegregation is defined as occurring when a group scores at least 60 on four of five measures of segregation—evenness, exposure/isolation, concentration, clustering, and centralization (Denton 1994; Massey and Denton 1989; 1993)

⁶ Depending on the measure of centralization used, Iceland and Wilkes either report that 29 metropolitan areas or only 23 were hypersegregated in 2000.

may be majority-minority before the 2020 census (Frey 2011; Passel, Cohn, and Lopez 2011). This immigration has major impacts on measuring segregation given that most traditional measures of segregation compare only two groups at a time, even as American cities have become increasingly multiracial (Iceland 2009). This requires that research be careful and explicit when deciding how to define segregation. First, recent immigrants often will increase segregation as they gravitate to ethnic enclaves (Alba and Nee 2003; Fischer and Tienda 2006; Iceland and Nelson 2008), which may obscure the relative integration of multigenerational Asian and Hispanic populations compared to the black population as immigrants are much more likely to be Asian or Hispanic than black. Glaser and Vigdor's (2012) results with regards to the decline of segregation are largely skewed by treating black-Asian and black-Hispanic integration as equal to black-white integration, while others have shown that minority-minority neighborhoods are still substantially disadvantaged compared to majority white neighborhoods (Peterson and Krivo 2010). A similar problem exists in the multigroup entropy index (Iceland 2004), which treats all groups as equals in creating a single metric of segregation. Other scholars resolve these problems by reporting multiple results for each different racial combination (Logan and Zhang 2010; Logan, Stults, and Farley 2004; Frey and Farley 1996), an unwieldy but more careful presentation of results.

The other substantial trend is the sustained exodus of white populations from the urban core. By 2000, eight of the 50 largest metro areas were majority non-white. By 2010, sixteen of the top 50 metro areas were majority-minority, including five of the ten most populous. In addition, over half of the 200 largest cities in the United States were

majority-minority. While the bulk of these metro areas are found in California and Texas, they also include the Washington, DC metro area and the Detroit area for the first time. These new racial demographics may lead to new forms or geographies of racial segregation, as the proportion of the minority population that is black is associated with the level of segregation of blacks in a metropolitan area (Farley and Frey 1994). In sum, while segregation has declined since the 1980s and that decline may have begun to accelerate since 2000 (Logan and Stults 2011), black-white segregation continues to be endemic to and remains the “structural linchpin” of race relations and inequality in the United States (Bobo 1989).

Theories of Segregation’s Origins

The empirical evidence convincingly shows that segregation is a persistent structural reality in society, particularly for black Americans. While segregation’s continued existence is rarely doubted, its principle cause is a subject of considerable controversy, as with many forms of racial inequality. Most scholars accept that segregation is caused by a wide array of complex and associated factors, though scholars disagree on the relative impact of the different influences (Adelman and Gocker 2007). Three groups of factors are most commonly referenced in the literature: individual preferences, class inequality, and discrimination.

Role of In-Group Preference

The primary non-structural explanation for the persistence of racial residential segregation is that individual residents' racial attitudes affect where they are willing to live. Growing from the common sense idea that like prefers like, residential segregation is reinforced and recreated because different racial groups have different preferences and/or tolerances for neighborhood integration. A stable, integrated neighborhood is actually a mathematical impossibility if different racial groups have different preferences for integration or segregation (Friedman 2011; Bruch and Mare 2006; 2009; Schelling 1971; Clark 1991). While the original Schelling model that first proved that stable integration cannot exist needed some revisions (Clark 1991; Bruch and Mare 2006; 2009), evidence strongly supports its basic argument at both the neighborhood level (Charles 2003; 2006) and the micro level of proximate neighbors (Friedman 2011).

These individual preferences, it should be noted, are strongly influenced by the structure of society. If black neighborhoods had not been so severely neglected for decades and had white neighborhoods not received as much governmental and bank support, the stigma that individual white homeowners may have against black neighborhoods would likely be lower. Similarly, if previous generations of white residents had not so aggressively fought integration, perhaps more non-white residents would prefer to live in even more integrated neighborhoods. Even a seemingly non-structural explanation for residential segregation is, in reality, the internalization of the racial hierarchy of society (Bonilla-Silva 1997; 2008).

Most scholars who study the impact of in-group preference highlight the impact of white residential preferences, as both the privileged group and the numerically largest group (Massey and Denton; 1993 Farley, Schuman, Bianci, Colasanto, and Hatchett 1978). A few scholars argue that minority resident's in-group preferences have substantial impacts on the perpetuation of segregation (Clark 1991; Thernstrom and Thernstrom 1997). However, minority respondents in surveys routinely report desires to live in more integrated neighborhoods than white respondents (Bobo and Zubrinsky 1996; Charles 2006) and individual preferences to live in a segregated neighborhood is largely based in minority respondents' fear of white hostility (Krysan and Farley 2002). In her study of proximate neighbors, Friedman notes that the majority of the research in the field of racial preference and segregation "finds support for the negative out-group preferences [of white residents]...arguments in explaining why residential segregation persists between whites and minorities." (2011; 16)

Role of Class/Wealth Inequality

Much of the racial divide in arenas such as educational attainment can be explained by the racial inequality in wealth (Conley 1999). The argument is simple: the continued existence of racial inequality is due to the continued association between race and class. Thus, if all racial groups had equal socioeconomic statuses, residential segregation would be greatly or possibly entirely diminished. Unfortunately, while

socioeconomic status does provide better access to integrated neighborhoods, this does not explain the extent of racial segregation seen today.

Race and class are greatly entangled in society, to the point that some scholars have proposed a “proxy” hypothesis in which racial segregation is perpetuated due to class prejudices (Clark 1988; Ellen 2000). Because individuals like to live with people of similar class backgrounds and because of the large race-based class differences, individuals may use race as a proxy for class when selecting a neighborhood. This proxy hypothesis, however, is generally not supported by the empirical evidence on racial and class preferences (Bobo and Zubrinsky 1996; Charles 2006; Friedman 2011).

Quite simply, class does not explain more than a substantial minority of the amount of segregation in American society (Charles 2003; 2006). As Spivak and colleagues conclude “the higher level of integration experienced by black households as their income increases is still relatively modest when compared to the substantial level of segregation that is present for even the most affluence black households.” (2011; 561)

Role of Discrimination in the Housing and Credit Markets

Seeing how both in-group preference and class differences only explain part of the persistence of racial segregation, a substantial part of racial segregation remains unexplained. While legally outlawed, research has demonstrated that racial discrimination continues to play a powerful role in perpetuating residential segregation.

In a review of the scholarship on discrimination, Pager and Shepard (2008) highlight two key mechanisms that continue to contribute to racial residential segregation: access to real estate information and lending discrimination. While redlining is prohibited by law, audit studies show that real estate agents continue to offer black home buyers and renters worse information, to steer them into less wealthy neighborhoods with higher proportions of minority residents, and offer fewer opportunities to visit potential units (Turner and Ross 2005). As Pager and Shepard conclude, “Although there are some promising signs of change, the frequency with which racial minorities experience differential treatment in housing searches suggest that discrimination remains an important barrier to residential opportunities.” (2008; 189)

This discrimination does not end once racial minorities purchase or rent a new home. Black residents receive worse maintenance and complain of unequal treatment and harassment by neighbors (Roscigno, Karafin, and Tester 2009). Discrimination may have its largest and most pernicious effects within the credit markets, to the point that research refers to a “dual-mortgage market” based on race (Immergluck and Miles 1999). Black and Latino applicants were substantially more likely to be rejected for loan applications than comparable white applicants (Ross and Yinger 2002), and when they do receive mortgages, pay higher rates (Oliver and Shapiro 1997).

One of the main arguments used by conservatives to explain the housing crisis of 2008 was that banks had been forced to make risky, often subprime loans to minority communities. At a fundamental level, this criticism is ahistorical. The “risks” that banks

attributed to those neighborhoods are largely legacies of the segregation and malign neglect those same banks supported for decades before being forced to change their lending policies. At a simpler level, this criticism misses the continued discrimination black and Latino homeowners face in the credit market. Not only are minority applicants more likely to be rejected, but when they do receive mortgages, they are more likely to be offered subprime or predatory loans that often were not correlated with expected rates of default (Williams, Nesiba, and Diaz McConnell 2005) that some called the “new inequality” even before the housing market collapsed (Holloway 1998). This is true even at higher income levels; just as with segregation patterns, class differences do not explain the racial differences in credit opportunities. In fact, some research shows that the unequal access to traditional mortgages explains the racial difference in foreclosure rates during the housing crisis (Reid and Laderman 2009)

Neighborhood Effects: Mechanism for Inequality

Segregation is a principal organizing factor of American society, regardless of one’s theoretical orientation toward its causes and perpetuation. As such, any research into spatial effects, neighborhoods and individual (or macro) outcomes, or inequality is either explicitly or implicitly studying the causes and effects of segregation in society. The next section addresses some of these implications of racial segregation and neighborhood inequality by looking more closely at the revived interest in neighborhood effects research. While that work has reignited interest in the neighborhood as an

important meso-level of social organization within a city, it has gone without a central theoretical framework (for efforts toward such a framework, see Blasius, Friedrichs, and Galster 2007; Sampson 2012), and rarely directly connects its findings to racial residential segregation as a key, if not the key, structure underpinning all the findings relating individual outcomes to contextual factors.

Early urban ethnography often looked at a neighborhood instead of the individual, particularly the Chicago school's early classics like *The Gold Coast and the Slum* (Zorbaugh, 1929) or *The Ghetto* (Wirth, 1928). As ethnographic methods improved, however, the interest of most urban ethnography shifted from the neighborhood and its general structure to a more detailed analysis of individuals and their behavior in the city, from the behavior of homeless booksellers in a particular neighborhood of New York in *Sidewalk* (1999) to Eli Anderson's work on Philadelphia (2000), to more recent work on policing and its impact on individuals (Goffman, 2009). Unfortunately, while the neighborhood is often a critical factor in organizing these effects—homeless booksellers are restricted to one liberal neighborhood in New York; neighborhood context influences what “code” to use in a given encounter; and aggressive policing in Philadelphia is restricted to non-white neighborhoods (Bourgois personal communication)—it is in the background of most urban ethnographies.

The neighborhood is also traditionally treated as a static background component in quantitative urban sociology (Crowder and South 2007; Friedman 2004). Most quantitative urban sociological work has looked at either micro or macro level events,

such as how attitudes affect urban segregation (Charles 2006) or how segregation levels vary across cities in the US (Iceland 2009). At the same time that ethnography has moved away from studying the neighborhood, quantitative sociologists have recently shown great interest in bringing the neighborhood back into urban sociology, pioneered mainly by Robert Sampson's work on collective efficacy (Sampson, Raudenbush, and Earls 1997). However, this work has undertheorized both the importance of segregation on those effects (Peterson and Krivo 2010) and the neighborhood itself (Grannis 1998; 2005; 2009). One possibility is that researchers have accepted Massey and Denton's insight that racial segregation in a racially unequal society inherently concentrates the disadvantages and inequalities visited upon minorities within the segregated communities. That is, every neighborhood effect found in sociology is caused, at least in terms of its magnitude, by racial residential segregation. More pessimistically, it is also possible that the research on neighborhood effects sees segregation as associated with but not causal to contextual effects. In a racialized society that attempts to obfuscate the impact of the racial structure on individual outcomes (Bonilla-Silva 1997; 2008), research should be more explicit about its theory of causation, else it may be misused and misapplied both inside and outside of the academy (Zuberi and Bonilla-Silva 2008). Neighborhood *effects* are an exciting topic of study in urban sociology, but not the neighborhood itself. Urban space is not created equal, as neighborhood effects research argues, context matters, but in particular one's neighborhood matters. But, what exactly is a neighborhood, how big is it, and how strongly does it affect the importance of context?

Neighborhood Effects Findings

In the past 20 years, neighborhood effects have captured the imagination of urban sociologists (Sampson, Morenoff, and Gannon-Rowley 2002). Few other concepts have seen such explosive growth in interest in the field—one that took off in the late 1990s and has continued through the 2000s unabated (Fearon 2003; Morenoff and Lynch 2004; Sampson 2012). Interest grew in part as sociologists began to incorporate spatial analysis into their models, which allowed researchers to more accurately model effects that occur in space. As georeferenced data and spatial analytic tools have become more accessible to sociologists, sociologists have built more and more impressive regression models to capture the effect of spatial context on a variety of outcomes, from crime (Sampson, Raudenbush, Earls 1997; Hipp 2007) to education (Sampson, Sharkey, and Raudenbush 2008) to health outcomes (Matthews, 2008; Mujahid, Diez Rouz, Morenoff, and Raghunathan 2007).

Neighborhood effects research has become quite popular throughout the social sciences had even though some early work questioned the field (Jencks 1989) and others criticize it as undertheorizing and overpromising (Messer 2007), the work has steadily grown more popular and more accessible to researchers (Anselin 2009). Unfortunately, while the ability to perform spatial analysis has improved, few scholars have grappled closely with the theoretical problems unique to neighborhood and spatial research (Messer 2007). Nonetheless, the recent work has provided rich new ideas to the social sciences that I will discuss in brief here. As one survey of the research in neighborhood

effects in economics notes, “the neighborhood effects literature is quite disparate and no survey could cover the full range of theoretical models and empirical studies contained in the existing literature.” (Durlauf 2004: 7). In fact, there have even been disparate literature reviews ranging from those focused on the many methods available (Anselin 2009) to those focused on sociology (Sampson 2002), the social sciences more broadly (Fearon 2003), public health (Ricketts 2003; Rushton 2003), and even a public health review from 2004 (Morenoff and Lynch 2004) that cited an already outdated review of neighborhood effects and health outcomes from 2001 (Pickett and Pearl 2001). One of the most interesting similarities across all of these reviews is one critical and underappreciated flaw in neighborhood effects is the inadequate consideration of exactly how, geographically, to identify the neighborhood (Galster 2008; Durlauf 2004). For the sake of brevity, I will focus my review here on some of the most popular and consistent findings in the neighborhood effects literature, particularly in two areas: health outcomes and crime.

Empirical Findings in Public Health and Criminology

Amongst social scientists, one can argue that public health researchers have been the most interested in uncovering the role of neighborhoods and social context recently. On a variety of health outcomes, including mortality (Morenoff and Lynch 2004), cardiovascular health (Mujahid et al. 2007; Messer 2007) birthweight (Buka, Brennan, Rich-Edwards, Raudenbush, and Earls 2003, Morenoff 2003), and mental health

(Levanthal and Brooks-Gunn 2003). Unfortunately, while public health research has embraced multilevel empirical studies that look at individual effects and neighborhood effects on health outcomes, theorization on how neighborhoods affect health remains woefully underdeveloped. In a review of the literature in 2001, Diez Rouz wrote “many of these [conceptual and methodological] issues stem from the need to develop theories and more specific hypotheses on the dynamic processes through which neighborhoods and individual factors may influence specific outcomes” (2001: 1784). Unfortunately, that advice seems to have fallen on relatively deaf ears as Messer repeats the same concerns in a criticism of a neighborhood effects study six years later. The response of the researchers (including Diez Rouz) is, unfortunately, telling: “Our paper is merely a methodological illustration, with no grandiose theoretical aims....Theorizing on the spatial scale at which different area processes operate is obviously important, but unfortunately there is very little information on which to base this theory” (2007: 872). While their work provides a methodological framework for measuring ecological/social context, it still leaves unanswered important questions of scale and the process through which context affects health.

The criminological research that focuses on neighborhood effects has the opposite problem from the health outcomes research. Social scientific studies of crime have long considered the effect of the neighborhood theoretically (consider Crane 1991 or Sampson and Groves 1989) and empirical studies of neighborhood effects and crime have introduced and tested theoretically grounded hypotheses, most prominently *collective efficacy* (Sampson, Raudenbush, and Earls 1997). Further, while health researchers have

discussed but never studied problems of scale (Messer highlighted in her critique the fact that Diez Roux and colleagues presented two different scales for defining a “neighborhood” but did not actually compare findings across the scales!), criminologists have empirically demonstrated the importance of identifying the proper scale of measurement (Hipp 2007). As Hipp argues, “the common strategy of measuring structural neighborhood effects...rarely considers whether this particular geographic unit is actually appropriate for the outcome of interest or the structural predictors being used.” (2007: 660). While this problem is critically important, researchers have nonetheless found links between a variety of contextual factors and crime rates such as neighborhood segregation and crime (Krivo, Peterson, and Payne 2009; Peterson and Krivo 2009), neighborhood poverty and crime (Krivo and Peterson 1996; for opposing views, see Rountree and Warner 1999), and a positive effect of homeownership on crime (Peterson, Krivo, and Harris 2000). Again, as Hipp notes, much of the research finds mixed results possibly because of inadequate consideration of the level of aggregation (Hipp 2007). Unfortunately, Hipp himself uses the theoretically dubious census tract (like many of the papers cited here and in his article) as one of his comparative levels of aggregation.

Neighborhood effects research is not limited to crime and health outcomes. For example, neighborhood context has also been used to help model residential mobility (Sharkey and Sampson 2008) and one recent article showed that both local and nearby neighborhood racial composition affects mobility—a finding that helped explain the relatively weak effects of local neighborhood indicators on residential stability (Crowder and South 2007). Neighborhood context and collective efficacy has also been linked to

age of sexual initiation (Browning, Leventhal and Brooks-Gunn 2004), verbal capabilities of African-American children (Sampson, Sharkey and Raudenbush 2008) and educational achievement (Jargowsky, El Komi 2009; Ensminger, Lamkin, and Jacobson 1996).

Interest in the neighborhood fell in the 1970s and 1980s, potentially because the conceptually important neighborhood was not easily transformed into statistical methods of the time (Guest and Lee 1984). Regardless of the reason, while neighborhoods are behind many of the important findings of urban sociology during that era, they were rarely discussed in detail. For example, William Julius Wilson's *The Truly Disadvantaged* (Wilson 1987) focuses greatly on spatial mismatch and the problem of unemployment, but barely mentions the neighborhood as organizing that segregation and unemployment. It was enough that there was segregation—exactly how that segregation looked geographically was secondary to its existence. While implicitly a part of Wilson's argument, the interaction between neighborhoods was never explicitly theorized⁷.

Unfortunately, these articles rarely look at how neighborhoods interact and the role of boundaries, critical areas for understanding how and why context matters. That undertheorized approach to inter-neighborhood differences has taken hold even as computational advances have allowed for the re-introduction of proxies of the

⁷ Outside of sociology, some scholars have theorized about the built environment either limiting or supporting interaction across neighborhoods (Harvey 2000). For example, activist-scholar Mike Davis has shown provocatively that the architectural design of seemingly public spaces such as the library and malls in Los Angeles are designed to discourage their use as a public space (Davis 1992).

neighborhood into quantitative urban sociology. Paradoxically, perhaps, as quantitatively the neighborhood is undergoing a resurgence as a topic, theorizing about the neighborhood has taken a backseat. While some work has attempted to bridge that gap by considering methodological concerns such as the modifiable areal unit problem as conceptual/theoretical concerns (see, Galster 2008; Messer 2007), those efforts have been relatively rare. In more technical terms, defining the boundaries of a neighborhood is an example of the modifiable areal unit problem (MAUP). A commonly discussed but rarely directly addressed issue in sociological literature on neighborhood effects, MAUP is the term used for the fact that different levels of spatial aggregation can lead to startlingly different results using the same data and space. Instead of addressing such concerns as conceptual problems that require novel means of studying them, more and more sociological research has addressed these concerns as purely methodological problems to be resolved via new statistical advances. In the early part of the decade, that meant using spatial regressions—tellingly, one type of spatial regression is also known as a “nuisance model” (space was a nuisance to be controlled for instead of a varying aspect of reality to be studied in itself) of spatial autocorrelation⁸ (Anselin 1992). More recently, geographically weighted regressions (GWR) allow for the effect of spatial context to vary for each observation in a sample (Sampson and Graif 2009). GWR is an improvement

⁸ Spatial autocorrelation is the co-variation of properties in a given geographic space. That co-variation violates the assumption of independence required for most regression analyses and has led to the development of spatial analysis to control for the spatial dependence of observations in a given geographic space.

statistically, but it still treats the variation in spatial autocorrelation as a bias in the error term of a model instead of as a conceptually meaningful and important focus on research. While GWR offers more accurate models of the question of interest within a neighborhood, these statistical advances obfuscate the related question of *why* there is variation in spatial autocorrelation in a geographic space and how individuals might manipulate that variation.

Methodologically, two patterns have emerged in work on urban space and the neighborhood. In the more common pattern, the census tract is used as a proxy for urban neighborhoods (Crowder and South 2007; Jargowsky 1997), which may represent a significant measurement problem (Steinmetz and Iceland 2003; Hipp 2007). Second, some more statistically rigorous work has attempted to mitigate that measurement error by clustering census tracts based on “geographic boundaries (for example, railroad tracks, parks, and freeways) and knowledge of Chicago’s neighborhoods” (Sampson, Raudenbusch, and Earl 1997). While such neighborhoods might be an improvement on census tracts, the process is unreliable, as scholars have shown that individuals do not agree on where neighborhood boundaries are (Guest and Lee 1984; Grannis 2009).

If all urban space were equal, then the spatial analysis would be simple—draw a circle of a certain distance around each individual and that would be that person’s neighborhood. Some have used that to challenge sociologists’ traditional measures of segregation by comparing geographic scales (Lee, Reardon, Firebaugh, Farrell, Matthews, and O’Sullivan 2008). While that research has intriguingly found that

segregation levels varies depending on geographic scale, it does not analyze the social aspect of urban space. Early interview research indicated that neighborhoods are more a social concept than a spatial one (Guest and Lee 1984). More recently, Galster (2001) confirmed that a neighborhood's geographic scale varies for an individual depending on what social process an individual is using to define the neighborhood at that time. That is, people define their neighborhood not by spatial proximity to others, but where similar people live, work, and/or play nearby. A neighborhood is both a social and a spatial means of dividing the population in space. Therefore, any purely spatial measure of segregation will mismeasure segregation in terms of lived experience in neighborhoods. If we are poorly delineating where neighborhoods begin and end, we are mismeasuring neighborhood effects and levels of segregation.

My current neighborhood in Philadelphia is a good example⁹. Broad Street is a major street that divides Philadelphia spatially east and west. To the west of Broad Street just north of the central downtown area, is a neighborhood that consists primarily of young urban white professionals and graduate students in recently rehabbed brownstones and new condos. Just blocks over on the East side of Broad Street is a neighborhood with significantly higher vacancies that is predominantly black and Latino that has not seen much new building in the past decade. Using Reardon and colleague's (2009) methodology, my local neighborhood would be integrated because of the large non-white

⁹ See data and methods chapter for more information about Philadelphia and its neighborhoods.

population East of Broad, even though no resident west of Broad would consider the residents east of Broad to be in their neighborhood (and vice versa).

Sociology and Space: Theoretical Concerns

Since the late 1990, sociologists have bemoaned the lack of a sociological theory around space. Tickamyer deplored space's "poorly specified place in sociological theory and research" (2000: 806), expanding further to note that "Sociology, despite its deep stake in understanding spatiality, has been inconsistent in its efforts to analyze this component of social life, and has made little forward progress in systematically incorporating it into its central project." Similarly, Lauren asserts "urban social research on inequalities has tended to take space for granted, drawing on it implicitly in their analyses yet failing to fully consider its effects and power in reproducing social inequalities or as a tool for social actors." (2008; 46) Early efforts to incorporate the insights of geographers such as Harvey (2000), Lipsitz (2007), and urban historians like Davis (1992) into a sociological theory of racialized space have only just begun (Neeley and Samura 2011) and admit to providing more questions than answers to date.

Gans, in a less pessimistic tone, asserts instead that "spatial sociology is reemerging from a long hibernation." (2002: 334) While Gans finds that a sociological study of space has re-emerged and cites encouragingly from the Chicago school's earlier works as a starting point for sociological studies of race and inequality, he cautions that studies of neighborhood effects is a misspecification: "Even if neighborhood is properly

defined, it is still only a bounded area, not a collectivity—such as a political district—with resources, power or even neighborhoodwide support systems that can influence what people do or what happens to them...Even if it were possible to prove that the combined efforts of all agencies and facilities inside a neighborhood had an effect on the residents, the cause remains in the agencies and whatever political and other efforts made their combination effective.” (334) Gans argues for a spatial sociology based on the idea that “individuals and collectivities shape natural and social space by how they use these, although each kind of space, and particularly the social, will also have effects on them.” (330). Outside of sociology yet still within the realm of social scientific work on race and space, George Lipsitz argues for a neo-Marxian understanding of space’s role in racial inequality. Lipsitz observes that “the lived experience of race has a spatial dimension, and the lived experience of space has a racial dimension.” (2007: 12). He returns to that idea to note that political opinions “represent the experiences and opinions of different *races*, but they have been less discerning about the degree to which these differences in views stem from the experience and opinions of different *spaces*.” (14)

These occasional and sporadic attempts to theorize a sociological understanding of space and social inequality struggle to advance the topic because they lack the rich, empirical data that can provide the basis for theoretical improvement. Neighborhood effects research, seemingly the most obvious basis for that empirical data, has not grappled directly with the misspecification problem those so concerns Gans. Such problems, to neighborhood effects researchers, are traditionally treated as measurement error, “spatial nuisances” to reduce via methodological innovations to traditional

regression models, or a caveat to be mentioned in a piece's introduction or conclusion and ignored in the analysis. This may be, in part, because such research takes the neighborhood as the starting point for their research question: to doubt the neighborhood as a concept or problematize it spatially and/or sociologically would make it nearly impossible to then study the neighborhood's "effects." A misspecification cannot have effects—thus, researchers have looked to improve methods to resolve the misspecification concern empirically without grappling with it theoretically.

Another possibility is that sociology has not incorporated space into its analytical and theoretical orientation to studies of inequality because there is little need to incorporate space to demonstrate the enduring nature of inequality or its effects on individuals and groups. Racial inequality, in particular, has been so egregious that even without a spatial analysis, the stark differences in outcomes, living situations, and opportunity have been identified, analyzed, and theorized about without significant concern for spatial analysis. Aspatial analyses of spatial stratification, while imperfect, are good enough to capture the basic reality of the reality of segregation and its lasting effects. In addition, the aspatial methods had the benefit of continuity; the index of dissimilarity has been used to measure segregation between blacks and whites since at least the 1960s (Taueber and Taueber 1965). Replacing an index that has been in use for decades may enhance the accuracy of current research efforts, but at the risk of making a longitudinal comparison difficult or even impossible.

Nonetheless, a growing number of sociological works on racial inequality has begun to incorporate space into traditional fields of inquiry. These works have both shown the possibilities, and pitfalls, of incorporating space into sociological inquiry and have made substantive, empirical and theoretical improvements to sociological understandings of and ability to analyze racial inequality.

The Chicago School and Boundaries

In his study of the trajectories of Chicago's "natural areas" and communities nearly 50 years after Park and Burgess first delineated the 75 "natural areas" of Chicago, Albert Hunter asserts that "to be able to name an area is in no small way to know it." (1982: 68). Hunter found that those 75 natural areas were further segmented into roughly 200 "symbolic communities" of more variable names and sizes. Some areas had very clear boundaries in 1968 when he conducted his interviews, while others were in the process of merging or dividing with their neighboring communities. After another 40 years of time, Chicago was divided once again by a sociologist interested in neighborhoods and neighborhood effects, this time in 343 "neighborhood clusters." (Sampson 2012) Sampson's work has been an invaluable addition to the research on contextual effects and how structure informs and affects neighborhood effects on individual outcomes. Unfortunately, Sampson is an example of sociology's interest in neighborhood effects that takes spatial context as an important variable of interest, but does not directly theorize about how geographic space becomes social space, where that

happens, and what that process means. While a substantial theoretical and empirical improvement over the more common aspatial studies of individual choice and outcomes of other scholars, this may be why Sampson summarizes his findings as “a family of neighborhood effects, an example of *contextual causality*” (383) and not as a finding of spatial or even socio-spatial causality.

Social science research that has incorporated space into studies of racial inequality generally finds that outcomes such as crime rates, health, and educational attainment in a given census tract or neighborhood cluster are associated with the quality of the neighborhoods or tracts surrounding the census tract of interest (Peterson and Krivo 2010; Sampson 2012). However, in doing so without carefully analyzing the boundaries between their neighborhood proxies, these efforts cannot determine whether their findings are due to inter- or intra-neighborhood spatial effects. In other words, it is possible that their findings are either those spatial effects are intra-neighborhood effects and their proxies for neighborhoods are geographically too small, or they may be inter-neighborhood effects and their proxies are the right size (or too big). Instead, this project studies not the neighborhood effect—something that requires an *a priori* definition of where neighborhoods are and where they end—but rather, boundary effects. As Al Hunter points out in his mixed-methods study of Chicago neighborhoods in the 1960s and 1970s “Such ambiguity also means that maps outlining local areas, such as this research has produced, are only reifications, although sometimes “useful” ones, of the complexity and diffuseness of local areas as objects and settings for social life” (Hunter 1982). Studies of these reifications, while helpful in identifying the interplay between

geographic context and racial inequality, continue to make that same mistake. At this point, the sociological concern over inaccurately proxying neighborhoods is little more than a standard caveat somewhere in the data section of a book or article.

There are two ways spatial effects can impact individuals: proximity (geographic spatial effects) or via symbolic boundaries (social special effects). The first is the more intuitive method. Simply put, things that are near to an individual are more likely to impact that individual than things that are further away. For a positive example, being near a well-financed park and recreational area provides an individual with access to space for exercise and a healthier lifestyle. Similarly, being close to a grocery store makes it easier to eat healthily, while being far from grocery stores but close to fast food restaurants may have the opposite effect and may be related to obesity rates (Kwate 2008). Of course, geographical space is not always neutral; large hills or rivers may make things that are close in euclidean distance difficult to reach for the individual.

However, social structure can also impact those pathways. If the road to the nearby park is poorly lit and untraveled, it may be less safe to use at night and thus individuals may use the park for recreation less frequently. If there is a major road with 6 lanes that is difficult to cross as a pedestrian, that similarly may constrain park usage. Social structure can affect the role of space in both directions: well-lit roads, pedestrian walkways across major highways, and bridges over rivers can make access easier for pedestrians. This is similar to Davis' (1992) insights about how urban architecture can be used to identify who is and, more importantly for his study, who is not welcome to use

public spaces. Benches that do not allow individuals to lie down on them make them unsuitable for use as a sleeping area for homeless individuals. Walls or the visibility of security guards can make outsiders feel unwelcome in an area while making insiders feel particularly protected or isolated in the middle of the anonymous city (Wirth 1938).

Hunter, though he does not discuss the actual geography of Chicago, provides valuable insight into how a sociology that looks at how geographic space turns social might reconsider the questions of segregation and neighborhoods. Hunter asserts that not only does naming an area a way to know it (and to control it), but that boundaries are another significant component of the symbolic community, especially when it is conceived of spatially. Although the name of an area implies that it can be distinguished from surrounding areas, this distinguishing character becomes heightened as people are able to specify distinct boundaries. Within Hunter's theory of a "symbolic community," boundaries serve a cultural purpose that comes from its reality as a social fact. Boundaries distinguish the character of different communities. By being able to identify where a community ends spatial, one can know who is in a community and what the culture of that community is.

That insight leads to a second form of spatial effects: the social spatial effect. By creating a division between insider and outsider, boundaries can become symbolic boundaries as well (Lamont 1992; 2000). That is, those who are welcome within a geographic space then share a characteristic that can be used to justify and reify that division of people. In common slang, this is the basic idea behind terms like "wrong side

of the tracks.” Railroad tracks don’t just delineate racial and economic segregation (Ananat 2011), they also provide symbolic boundaries between the “right” and the “wrong” communities within a municipality. As Hunter continues:

Boundaries are significant not only for identification but for social action....Behavior as well as identity may change as one crosses a street and one’s status changes from “citizen” to “stranger.” Such symbols may themselves constrain, control, and direct behavior. If one is told that people on the other side of the tracks think and act differently, one may believe it and so never cross the tracks to test the “reality” of this shared definition. Furthermore, those across the tracks may think and act differently because they are “expected” to do so. (68)

Physical barriers can become more than symbolic boundaries between communities and neighbors but social facts as well. This argument is not novel to Hunter within the Chicago School tradition. In fact, Hunter himself attributes this basic point to Park:

“Geographical barriers and physical distances are significant for sociology only when and where they define the conditions under which communication and social life are actually maintained.” (Park 1925: 174). Boundaries only merit study *if* they are associated with differentiation of social life. The same is true of neighborhoods. Outside of urban sociology, that insight has been most forcibly identified and studied through the work of Michele Lamont (1992; 2000) using Bourdieu’s framework for her analysis. In Lamont’s studies of social class differences, she found that both working class and wealthy individuals create moral justifications or boundaries between themselves to explain

socioeconomic inequality and their individual positions within that spectrum of status. Importantly, this boundary work is done *from both sides* of the divide; working class individuals believe that elites do not have the same moral views and philosophies, and they prefer seeing themselves as moral actors instead of converting to the moral codes of the upper class in an attempt to improve their socioeconomic status. While this insight identifies the fact that boundary work can come from the less privileged of two groups, such a reality is not the case in terms of racial segregation. Non-white residents overwhelmingly prefer a more integrated neighborhood, but only sometimes achieve that neighborhood (Bobo and Zubrinsky 1996; Charles 2003; 2006; 2007; Timberlake 2000).

Sociology has an impressive mix of theoretical, qualitative, and quantitative studies that study the impact of neighborhoods or the effects of symbolic boundary work. Disappointingly, there exists no research that combines the two to focus on the impacts of physical boundaries—in fact, in a review of the literature on boundaries, space is only mentioned in the section on national boundaries and not with regard to racial or ethnic boundaries (Lamont and Molnar 2002). This is particularly tragic as one of the main findings of the sociological research on neighborhood inequality is its durability (Sampson 2009). If, instead of continuing to battle over that durable inequality and how to solve it, scholars and government officials were to identify boundaries and barriers and instead work to make them less impermeable, there may be a yet unexplored social policy direction for city officials to enhance efforts to desegregate cities socioeconomically and racially. If there is a clear distinction between a black and a white neighborhood, that will help reify racial and cultural segregation. If, however, one cannot identify the barrier

between the “good” and “bad” neighborhoods, or one makes that barrier a place of social integration and interaction, that boundary zone, that gray area, may become a truly integrative social space that could spread into both neighborhoods.

Hunter, in his conclusion, makes another point that is particularly relevant for today’s multiethnic city. Hunter shows that boundaries not only help to exclude outsiders, but can be a site for a form of social mobility. In Hunter’s words, “boundaries serve both inclusive and exclusive functions, as when residents of a higher-status community consciously or unconsciously drew sharp boundaries that excluded residents of an adjacent lower-status area, while the latter “blurred” these boundaries to include themselves within the higher-status community.” (192) Boundaries are a contested reality. For example, the simple existence of a multi-lane road exists does not mean it has to be a boundary between racial groups. Similarly, these boundaries may be recognized by some citizens but not others. Neighborhoods in transition may have unclear boundaries, and gentrification (or population desertion) may subsume former boundaries into key retail strips for new neighborhoods.

However, Hunter overreached by claiming that such contestation is a one-way process in which lower-status groups desire to be associated with a higher-status neighborhood. As Lamont shows in her book on working class identity (2000), lower status groups may, in fact, take pride in that identity and their unique character or history. In fact, such a process is occurring in South Philadelphia west of Broad Street and south of Washington Avenue. The area north of Washington Avenue has been undergoing

racial and class turnover due, in part, to its ideal location near both the central downtown area that was revitalized in the 1990s and the University of Pennsylvania, Philadelphia's largest non-governmental. That gentrification has moved steadily south and has begun to cross Washington Avenue, traditionally a strong neighborhood boundary delineating the northernmost edge of the Point Breeze neighborhood. Point Breeze has been a high poverty, predominantly black neighborhood for decades. In the past ten years it has seen increased immigration from Southeast Asia to replace a substantial loss of black residents. More recently, wealthier white families have begun to move there and the specialty shops often associated with gentrification—boutique coffeeshops and gastropubs—have begun to open. As I discussed earlier, these changes have provoked a strong backlash amongst the largely working class black long-term residents. Individuals may blur boundaries in order to associate with higher status communities, but they may also reify boundaries in order to protect their symbolic community.

Boundaries and Social Science from Outside the Chicago School

Rick Grannis saw the effect that major roads can have on urban residential space and coined the term “tertiary community” to analyze that effect (Grannis 1998; 2005). A tertiary community (t-community) is the group of individuals that one can reach without crossing a major thoroughway. Grannis' work is an improvement over the purely spatial measures described earlier because it accounts for a social component by arguing that one is more likely to socialize with neighbors that one can easily access physically. As he

notes, the modifiable areal unit problem (or MAUP) proves that the neighborhood is undertheorized as a level of analysis: “Those researchers who have developed methods for creating optimal zones with respect to predefined objective functions note correctly that MAUP would be irrelevant if areal units were chosen for theoretical reasons rather than administrative convenience.” (Grannis 2009) However, while Grannis’ network-based argument is a significant improvement, some of his evidence for t-communities relies on a slight straw man of a comparison: to either census tracts or a purely spatial measure of a neighborhood. While tertiary streets (defined as having one lane, and not having any median or divider, railroad alongside, or a tunnel) do provide more access between individuals, that definition is not always valid. Using Philadelphia again to illustrate, the neighborhood of Bella Vista crosses 11th street even after 11th street becomes a three lane road, and Walnut Street is not commonly seen as a divider between neighborhoods even though it is technically not a tertiary street.

In fact, while Grannis argues that tertiary streets are the most likely to encourage local and pedestrian traffic and therefore also social interaction, one can also argue that commercial streets or areas are more important for that component of “neighboring.” Jane Jacobs noted that mixed uses of an area were critical to a sense of neighborhood (Jacobs 1961). Jacobs argues that a neighborhood is not purely residential but also includes shopping and eating establishments as well to create more social relations. However, because tertiary roads do not attract traffic, they are likely to have less commercial business. Shopping strips on non-tertiary roads such as Germantown Avenue, Walnut Street, Girard Ave, or South Street in Philadelphia can either be clear dividers or

neighborhoods or the heart of a single neighborhood. In some cases, the same non-tertiary road might act as a divider in one area and a connector in another. Girard Avenue, for example, is a divider between Northern Liberties and Kensington until it reaches Front, at which point it is the main thoroughfare and commercial center for Fishtown. Grannis himself acknowledges that tertiary communities are, at best, a proxy for neighborhoods and only one of many possible proxies. In particular, Grannis' t-community concept is valuable for studies of social capital and collective efficacy as it is primarily concerned with residential social connections. In separate work, Grannis has found that the t-community as a proxy for a neighborhood is noticeably more effective at modeling the residential patterns of families with children (who might prefer smaller streets because they have children) than other residents of an urban neighborhood (Grannis 2005).

That flaw in the t-community as proxy of neighborhood may come from Grannis' theorizing the neighborhood as something that has an effect on individuals rather than as something of sociological interest itself (Grannis 2009). Sociologists, in fact, have rarely adequately considered the neighborhood itself to be of sociological interest. Throughout urban sociology's history, the neighborhood has been either an aftereffect of either a larger process such as urban renewal (Smith, 1996), or micro-level individual residential decisions (Sharkey and Sampson, 2008). Rarely has the neighborhood itself been studied without being seen as affected by or having an effect on something else. Those few studies that focus on the neighborhood itself have had to use census tracts as admittedly

flawed proxies of the neighborhood (Briggs 2004; Galster, Quercia, Cortes, and Malega 2003; Briggs and Keys 2009).

Another approach proposed by Glaster (1986) is to identify neighborhoods deductively by first identifying the particular neighborhood attribute of interest. He uses perceptions of neighborhood geography and impact as the critical defining characteristic of a neighborhood. He identified three features of a “neighborhood externality space” that would define a neighborhood: congruences (how much one’s perceived neighborhood corresponds to predetermined boundaries such as those of CDCs); generality (how much one’s externality space changes depending on the specific attribute being studies); and accordance (how much nearby residents agree on where the neighborhood boundaries are). If one can identify a set of boundaries with high accordance and generality, then one has identified a meaningful neighborhood “bounding.” As Galster notes in later work, “my definition does not lead to the Holy Grail sought by much neighborhood analysis of the 20th century: a means of unambiguously meaningfully bounding urban neighborhoods.” (2001: 20113)

Galster’s work resolves the methodological and theoretical concerns surrounding neighborhood effects research by making two subtle shifts in how social scientists approach the neighborhood. First, instead of beginning with the areal unit of “the neighborhood” as a known, geographically identifiable space within which things occur, Galster begins with an attribute of interest—housing cost, racial segregation, educational attainment, etc. The neighborhood is constructed based on that attribute and, thusly, the

neighborhood built around the externality of housing cost may be geographically distinct from the neighborhood built around educational attainment or racial makeup¹⁰. Galster's neighborhood begins by looking at boundary work and border processes. The neighborhood begins and ends where there is a noticeable change in attributes across a street or physical barrier of some sort. Most importantly for this current project, Galster's approach is a boundary and attribute oriented definition of a neighborhood. In other words, it is the *boundary between different social spaces* that is central to the definition of a neighborhood. If a boundary does not exist, the neighborhood has not ended. While individual residents of a particular space may argue that there are actually two (or more) neighborhoods being merged by that analysis, for the sake of social scientific research on inequality and neighborhoods, that is less relevant than correctly identifying where there are sharp boundaries for contextual neighborhood effects.

Philadelphia as Study Site

While some criticize single city studies for being potentially ungeneralizable (Peterson and Krivo 2010), and some have provided evidence that studies of Chicago

¹⁰ Of course, most scholarship has shown that these neighborhood attributes are highly correlated with each other. Nonetheless, it may be possible that a white middle class neighborhood is next to a similar Asian or Latino (or less commonly, Black) middle class neighborhood. In that case, the externality of class would arguably combine the two neighborhoods while the externality of racial segregation would separate the two.

may be guilty of that concern (Smalls 2007), the single city study is still common. While it may be less generalizable, it is replicable in other cities (see Sampson 2012 for a detailed defense of the single city study) and allows a researcher to combine his/her local knowledge—or that of respondents—as an additional resource while studying a city. As such, a single city study is particularly valuable when introducing a novel methodology to study neighborhoods; if racial boundaries are misidentified or exaggerated, simple spot tests and local knowledge can be used to test and improve the accuracy of the methods.

Most single city studies in sociology have been generated out of the Chicago School; by extension, Chicago is the most commonly studied city in the United States. Philadelphia and Chicago share some important historical and demographic profiles. Both cities reached their largest population in the 1950s and 1960s and lost substantial populations when manufacturing bases of employment left the American urban core and many residents left for the suburbs. Both have large black populations of roughly equal size to the white population with substantial and growing Asian and Latino immigrants. Both have continued to experience total population loss between 1990 and 2010. However, Chicago's population grew between 1990 and 2000 before falling again between 2000 and 2010. Philadelphia's population reached its nadir in 2000 and recently underwent a small increase between 2000 and 2010 (due to increased immigration by Asian and Latino families, as both the white and black population totals fell between 2000 and 2010).

Philadelphia's history between 1990 and 2010 provides a valuable mix of contexts to compare and study. Chicago has a long history of immigration, including a large Mexican population that has lived there since before the 1990s. Philadelphia, on the other hand, did not experience substantial in-migration until the 1990s and people of Asian and Latino descent only combined to be a total of roughly twelve percent in 2000. In short, Philadelphia in 1990 was almost entirely black or white, began to experience small immigration flows by 2000, and became a new destination city by 2010. Each immigration status for a city may be related to different segregation profiles, and Philadelphia has a relatively unique position as a city that experienced all three in the three census periods under study. Similarly, Philadelphia went from a city with a large minority of black residents. In 2000 it was almost exactly evenly split between white and black residents (45% of each with 10% Asian and Latino), and by 2010, due to the continued white exodus from the city proper into the suburbs and smaller black exodus, it now has a larger black population (43%) than white population (37%). Once again, between 1990 and 2010, Philadelphia has experienced three different racial splits—majority white, even mix, and then majority black—that may impact or be impacted by the extent of segregation in the city.

Philadelphia is also a hypersegregated city, one that exemplifies the hypersegregation of many of the Northeast's postindustrial cities that have struggled to reinvent their economies after manufacturing jobs left the urban core. The period between 1990 and 2000 includes the continued regression of Philadelphia's population and economy since its height as an industrial center in the 1950s and early 1960s. After 2000,

however, Philadelphia may have turned a new chapter, one of multiethnic immigration, an economy that is buoyed by large health and education sectors, and an in-migration of young, mostly white, professionals into the urban center even as even more white residents move to the suburbs. In addition, traditional aspatial measures of black-white dissimilarity show that Philadelphia's segregation, while still sixth highest in the nation, continues to fall from over .810 in 1980 to .765 in 1990 and .737 in 2010. If segregation boundaries persist even across those substantial macro-changes in the city, it would once again provide strong evidence that racial segregation is driven by far more than class inequality or individual preferences.

Theoretically, a final rationale for studying Philadelphia is that it is the setting for Du Bois' *Philadelphia Negro*. While the seventh ward is now split amongst three wards and cuts a swath through between three to five neighborhoods (depending on how one defines the nebulous border between Graduate Hospital and Fitler Square and whether or not one defines Bella Vista as reaching as far east as Broad Street, now more common after the destruction of much of the public housing in the area previously known as Hawthorne). Unfortunately, even though Du Bois's study created a fantastic baseline for the study of racial equality and segregation in Philadelphia, urban sociologists never followed it as its base of theoretical and empirical shifted to Chicago during Park's tenure. At the same time, Philadelphia's status amongst American cities fell as cities such as Los Angeles and Chicago overtook its economic and cultural importance to the country. To date, while some important qualitative sociological studies have used Philadelphia as their setting (see, in particular, Anderson 2000; 2011), large-scale

empirical studies of the racial inequality in Philadelphia began and ended with Du Bois. Partly in homage to Du Bois' innovative early work, this study focuses on Philadelphia's racial segregation.

Dissertation Plan

This dissertation is built around three empirical chapters that build upon each other to delve deeper into the potential for spatial analysis to enhance the sociological study of segregation and, by extension, neighborhood effects. In sum, the dissertation provides evidence that application of spatial techniques to studies of segregation provides multiple benefits to social scientists and policy makers and opens new avenues for sociological exploration. The dissertation concludes with a discussion of the impact of the empirical findings and their potential to impact future sociological research on racial segregation and racial inequality more generally, as well as potential policy impacts.

Chapter 2 lays the groundwork for that effort by introducing standard, aspatial techniques for measuring and analyzing racial segregation. The chapter then introduces the spatial critique of aspatial metrics and GIS techniques that have been offered to resolve those spatial concerns. It concludes by introducing non-Euclidean kernel density analysis, a spatial methodology that has yet to be used in the social science literature. In doing so, the chapter also discusses how I operationalize "barriers," a key conceptual methodological portion of the empirical work introduced in chapters three through five.

Chapter 3 is a study of where integration happens and whether or not it is stable over time. The chapter begins by incorporating NIS neighborhoods, a more accurate *a priori* definition of the neighborhood compared to the standard census tract, into the study of segregation. The use of the larger, more socially relevant NIS neighborhoods in the study of segregation provides the opportunity to identify neighborhoods with high or low internal integration. The chapter identifies two neighborhoods that appear to be stably integrated across three decennial censuses according to traditional measures of segregation. The chapter then analyzes those two neighborhoods, University City and West Mount Airy, spatially to determine whether or not the integration identified using indices of dissimilarity and isolation are supported via spatial analysis. The spatial analysis, using basic GIS raster techniques, clearly identifies a regression toward segregation that highlights the significant benefit of incorporating spatial analysis into sociological studies of segregation and the importance of considering not only indices across entire metropolitan regions, but also local patterns of segregation.

Chapter 4 follows recent innovations in residential segregation research by incorporating kernel density analysis into the measurement of residential segregation in order to avoid the need to define local neighborhoods before measuring a city's segregation. Unlike previous work which did not incorporate any information about the local geographic and social space into their kernel density analysis, I introduce the use of "friction" to study whether or not the geographic space in which populations segregate impacts the overall level of segregation. Results provide both reassurance and reason for concern with regard to previous analyses of segregation. While the impact of including

friction at barriers such as major roads, railroads, or rivers is generally small on the city's reported level of evenness, it does show that the macro-segregation identified by Reardon and colleagues (2008) is, at least in Philadelphia, an artifact of not including barriers into the calculations. The chapter, building on the insight of Chapter 3, concludes by studying the local patterns of barriers, identifying exactly where and how barriers influence the level of segregation reported in Philadelphia and the importance of including them as a means of better identifying the overall pattern of segregation in a city and what geographic and social realities may help to explain those patterns.

Chapter 5 focuses on the barriers themselves. As Chapters 3 and 4 show, defining a neighborhood before measuring its segregation is a methodological assumption that had, until now, been necessary to study residential segregation. Fortunately, spatial analysis allows the researcher to avoid making that assumption which may bias studies of segregation. In addition, the introduction of non-Euclidean kernel density analysis also provides the opportunity to study the boundaries between racial groups instead of the neighborhoods themselves. That is, the chapter shifts away from the conceptually fuzzy idea of the neighborhood to focus instead on a more easily definable part of the city: the impact of barriers. The chapter introduces a measure of rate-of-change to identify where racial boundaries exist, whether or not such boundaries are associated with barrier type, and which boundaries persist over time. In the end, having identified which barriers are persistently strong, the chapter hypothesizes about potential reasons why certain roads or railroad tracks are consistent and strong boundaries while other, similarly major roads or railroad tracks, are not.

The dissertation concludes, in Chapter 6, with a detailed discussion of how the introduction of more spatially-aware methods and research questions challenges and supports traditional sociological understandings of segregation trends and causes. It further discusses how spatial analysis provides sociologists with two ancillary benefits to better communicate with and influence policy decisions and public awareness of sociological knowledge and to better engage our research with the theoretical and methodological advancements that integrating GIS into academic research can provide.

Chapter 2:

Data and Methods

Population data for this project come from the 1990, 2000, and 2010 censuses. As with the bulk of sociological work studying segregation, all individuals who report a Hispanic ethnic background were coded as Hispanic regardless of their racial identification. Individuals had the option in 2000 and 2010 to report more than one racial identity on the census. Aligned with earlier research in segregation, the work treats any individual who reported an African American/black identity as one of their identities as black, and anyone who reported an Asian identity but not a black identity as one of their identities were treated as Asian. Those individuals who reported multiracial identities that did not include Asian or black identities were removed from the sample population. In Philadelphia, Asian, Hispanic, white, and black residents made up well over 99% of the population using that coding scheme, as less than 1% of Philadelphia reported a Native American identity or refused to provide a racial identity.

Census data is publicly available only in aggregate form, at levels that range from the nation as a whole to individual blocks. Most studies of residential segregation use the census tract as a proxy for the local neighborhood. The tract is designed to be a relatively permanent division of a county with between 2,500 and 8,000 people in general, though some tracts have either higher or lower populations due to the location of large, non-residential spaces or the existence of large apartment complexes that are geographically

small but highly dense. The census bureau, when developing census tracts for a given city, attempted to develop geographic boundaries that contained as homogenous a population as possible at the time. Since introduced to a given location, the census avoids, whenever possible, changing the geography of census tracts unless it grows too populated (or shrinks until it is underpopulated) or new physical elements (the construction of a new highway or railroad, for example) demand that it be redesigned¹. Smaller than the census tract is a block group (tracts contain between 1 and 6 block groups). The block group are supposed to have between 600 and 3000 residents, but are not designed to be relatively permanent like a census tract. Finally, a census block is the smallest aggregation available from the census. Census blocks are formed by the combination of visible features that can be used as boundaries (streets, streams, railroads, etc.) and/or legal boundaries if relevant to that location. The census bureau does not report a desired population of individual blocks, as the block (unlike larger aggregations) is defined principally by the physical and legal geography and not by its population size or characteristic. In Philadelphia County, I use census blocks as the smallest available aggregation from the census bureau. Because of edge effects when incorporating spatial smoothing techniques (discussed in more depth later), I also incorporate block groups from the surrounding counties in Southeast Pennsylvania and New Jersey. For these areas, block groups are a small enough aggregation level to adequately address edge

¹ While the Census Bureau attempts to avoid changing census tract geography as a goal, the total number of census tracts identified for Philadelphia changed between each decennial census from 1990 to 2010. There were 365 tracts in 2000 and 390 in 2010.

effects without quintupling the size of the dataset as would be necessary were I to use blocks for those surrounding counties.

Census blocks are defined as the smallest geographic unit used by the Census Bureau for 100-percent data. In Philadelphia, census blocks are generally small and bounded by visible features such as streets or railroad tracks, and occasionally bounded by invisible features such as the transition from private property to public park space. Philadelphia blocks range in population from 0 (non-residential spaces such as industrial zones, parks, sports stadiums, etc.) to a high of 4,535 in 2010 (a large prison). Excluding four blocks with large prison or college dormitory populations, the most populated block in 2010 had 1,441 residents. In terms of physical size, census blocks range from 26 square meters to 3,487,501 square meters (this block includes the Northeast Philadelphia airport). Only 12 blocks are larger than 1,000,000 square meters, all of which are predominantly park or industrial space. The mean block is 19,585 square meters in area and has a population of roughly 80 residents. Roughly one quarter of all census blocks in Philadelphia contain no residential population. In 2000 the mean block was 21,335 square meters in area, and had 87 residents. In 1990, the mean block had 98 residents living in 22,922 square meters. Average population density per census block fell from a high of 4.27 residents per 1000 square meters in 1990 to 4.08 in 2000 and did not change between 2000 and 2010. That coincides with an overall population drop of roughly 100,000 residents between 1990 and 2000 and a small increase in population from 2000 and 2010 overall in Philadelphia. At the same time, the number of census blocks identified in Philadelphia grew from roughly 16,000 in 1990 to over 18,000 in 2010.

Parts of this dissertation compare two frequently used proxies for neighborhoods in research on residential segregation and/or Philadelphia. The first is the census tract, a relatively permanent aggregation level designed to have between 1,500 and 8,000 residents that has been the default proxy for neighborhoods in sociological studies of segregation and the neighborhood. The second proxy is a Philadelphia specific attempt to identify locally meaningful neighborhoods by planners and academics as part of the city's attempt to provide more access to demographic and other population data called the Neighborhood Information System, a joint project hosted by the Cartographic Modeling Lab at the University of Pennsylvania with the support of the William Penn Foundation and Philadelphia's city government. Neighborhoods were identified by planners and local residents in the mid-1990s, and unlike census tracts, have not changed their geographies since. While there are over 350 census tracts in Philadelphia, NIS identified 69 neighborhoods in the city. As such, the average NIS neighborhood is significantly larger than the average census tract, but its boundaries are consistent and are based in local knowledge of the local environments and communities of Philadelphia. NIS neighborhoods and data have been used by government offices, local non-profits and community development corporations, as well as academic researchers.

The Dimensions of Segregation

In a conceptually and empirically important piece, Massey and Denton (1988) helped to codify a measurement technique for analyzing levels of segregation that

combined multiple indices of segregation then available to researchers. As they noted, at the time there was little agreement as to what measures of segregation were most accurate and how, exactly, to operationalize the term “segregation.” As they noted “the field of segregation studies...[is] presently in a state of theoretical and methodological disarray” (282) Massey and Denton argued, using factor analysis, that segregation could be broken down into five dimensions:

- Evenness: The difference in the distribution of racial groups across spatial units in a city, measured by the index of dissimilarity.

- Exposure: The probability of contact or interaction between two members of different groups. It can also be measured by studying the probability of contact between two members of the same group and is then called “isolation.” Massey and Denton recommended the P^* index reintroduced by Lieberson.

- Concentration: The amount of physical space occupied by members of an individual group, or, that group's population density. Massey and Denton recommended the use of the RCO (Relative Concentration Index).

- Centralization: The location of the group's concentration relative to the central city area, measured by the ACC (Absolute Centralization Index).

- Clustering: The extent to which spatial units inhabited by members of one group are adjoined or located next to each other within the city, for which Massey and Denton recommended White's Spatial Proximity Index (SP).

Since Massey and Denton's piece, the use of alternative measures slowed considerably in the literature, but did not stop. In later work, Massey and colleagues (1996) recalculated their findings with additional data and found that their measures of clustering and concentration did not work as well as they previously thought. They argue that while centralization, clustering, and concentration are less relevant than previously thought, the original indices should continue to be used to maintain continuity in the research. Since then, a number of scholars have revisited Massey and Denton's basic framework and argued that the five dimensions can better be collapsed into either two or three dimensions (Johnston, Poulsen, Forrest 2009; Reardon and Firebaugh 2004). At the same time, Massey and Denton's preferred measures were aspatial indices, due to technical limitations at the time. Since GIS has made the creation, use, and interpretation of spatial measures of segregation available to researchers, multiple scholars have proposed the use of spatial techniques such as Moran's I (Johnston et al. 2009), the creation of spatially adjusted measures of aspatial indices (Wong, 1993; 2005), or the use of surface-density mapping (Kramer et al. 2010; Lee et al. 2008; Reardon et al. 2009).

This dissertation continues in that line of methodological critique by exploring the value of mapping as opposed to indexing measures of segregation, specifically in Chapter Three. In addition, Chapters 4 and 5 explore another alternative use of surface-density mapping techniques as well as an advancement of that technique to better map the uneven spread of a population across different urban surfaces that might act as barriers to interaction and, by extension, integration. The dissertation, in Massey and Denton's terminology, focuses primarily on considering the “clustering” of residents by race and

the spatial distribution of those clusters in Chapter 3, and then on improving the index of dissimilarity by using GIS and spatial analysis in Chapter 4, before turning to an alternative means of conceptualizing and measuring segregation that focuses directly on spatial residential barriers.

In general, the goal of this dissertation is not to offer yet another spatially-integrated measure of segregation or to argue for or against previously created indexes. Instead, the project hopes to illuminate the new and different research questions related to segregation that are explicitly spatial and, as such, were unavailable to researchers before GIS technology was developed. Thus, I briefly describe the measurement of evenness, exposure, and clustering, the three dimensions of segregation that I examine in different portions of the dissertation.

Evenness: Dissimilarity, Entropy Scores and Entropy Index

The large majority of sociological studies of segregation focus on evenness: that is, the level of variation of group population within subunits of the space. For example, consider a city that consists of three regions. One is 80% black and 20% white, the second one is 20% black and 80% white while the third is 60% black, 15% white, and 25% Asian. An observer would note that such a city would be extremely uneven in regards to the diversity of each region's population. Were the three regions to both contain identical proportions of black residents, it would be extremely “even.”

Traditionally in sociology, evenness as a component of segregation has been calculated

using the index of dissimilarity. Dissimilarity provides two main benefits as a measure of evenness: it is conceptually simple and it ranges from 0 to 1 and thus easily interpretable.

The index of dissimilarity calculates the percentage of a given group that would need to move from one subunit to another in order to create a perfectly “even” population. The formula for the index of black/white dissimilarity is:

$$D = 1/2 \sum \left[\left(\frac{b_i}{B} \right) - \left(\frac{w_i}{W} \right) \right]$$

where b_i is the black population in a subunit, B is the total black population of the entire area, w_i is the white population in a given subunit, and W is the white population of the entire area. The dissimilarity value for an area, then, is equal to the percentage of the black population that would have to move to a different subunit in order to achieve maximum evenness in that city. While dissimilarity has a long history of use in sociology and is elegant in its simplicity, it contains two flaws. First, dissimilarity is a *two-group* measure. Return to the hypothetical city described above. When calculating the black/white dissimilarity, regions 1 and 3 would both appear to have a black population that is four times larger than the comparable white population. The Asian population in region three would have no effect on the calculation of the index of dissimilarity. Second, as a formula, requires the use of multiple subunits to calculate the formula. Thus, it is difficult to identify where, within a given space, there is high or low levels of evenness using dissimilarity. In other words, dissimilarity identifies *that* a space has an uneven

racial distribution, but does not provide evidence (without the use of a second, unrelated measure of spatial distribution) *where* that unevenness exists.

The entropy score and its related entropy index resolve both of those problems associated with dissimilarity, but with their own flaws. In fact, Massey and Denton (1988) note that entropy is extremely highly correlated with dissimilarity and prefer to use dissimilarity not for a methodological value that entropy lacks but because dissimilarity has a longer history of use in sociology. With the increased immigration of Asian and Hispanic residents into cities that previously had almost exclusively white and black residents, entropy's ability to model both two-group and multi-group diversity and evenness has become more important to researchers. In a review of six multigroup measures of segregation, Reardon and Firebaugh (2002) and Reardon and O'Sullivan (2004) argue that the entropy index is the best measure available. I follow them and other sociologists (see Iceland 2004; 2009) and use entropy in sections of this dissertation to as an alternate measure of evenness. The entropy index measures the weighted average deviation of each subunit's entropy from the city-wide entropy score (E). The entropy score (E) is:

$$E = \sum P * \ln\left(\frac{1}{P}\right) + (1 - P) * \ln\left[\frac{1}{1 - P}\right]$$

A multigroup entropy score is a simple extension of that formula:

$$E = \sum_{i=1}^n P_i * \ln\left(\frac{1}{P_i}\right)$$

Where n = the number of groups of interest. Unfortunately, the entropy score is difficult to interpret because its range depends on the number of groups included in the calculation. For example, the maximum value for a two group Entropy score is 0.69, while a three group entropy score's maximum value is roughly 1.1, a 4 group score's maximum value is 1.39, etc. Nonetheless, the higher an entropy score, the more “diverse” an area's population.

Unfortunately, E is maximized when the population consists of an equal number of residents of each separate group. We know, however, that Philadelphia has large black and white populations with a small but growing number of Hispanic and Asian residents. As such, a neighborhood in Philadelphia that is perfectly integrated in comparison to the population of Philadelphia residents will not have the highest possible E score. In fact, only a hypothetical neighborhood with over five times the expected proportion of Asian residents, double the expected proportion of Hispanic residents and fewer than half the expected proportion of black residents would maximize E 's score. As such, E presents an inaccurate measure of evenness. E is also a non-linear measure of diversity, which causes a conceptual complication when comparing values (the difference between an area with a completely homogenous population and one with a 90/10 split is .325 on E , while the difference between 40/60 and 50/50 is only .02). This is an advantage of dissimilarity: because it uses the populations of the entire area under study as the denominator, it is minimized when every subunit has an identical racial makeup to the total population and its linearity ensures that any change in racial makeup of a subunit is treated equally,

regardless of that specific subunit's original value. E , then, is biased towards population in which each subgroup is equal in size.

Over the entire city, the entropy score is not the value of interest when determining “evenness” but rather the entropy index, or Theil's H :

$$H = \sum_{i=1}^n \left[\frac{t_i(E - E_i)}{ET} \right]$$

H is the weighted average deviation of each subunit's entropy (E_i) from the city-wide entropy score E . The entropy index, like the index of dissimilarity, ranges from 0 to 1 like the index of dissimilarity and the higher the score, the higher the level of unevenness. While H is not as conceptually elegant as D (the number of residents of a group that would need to move to create ideal levels of evenness), it offers the same information with the added benefit of being able to incorporate more than two groups at a time. In addition, because both E and H are based on logarithmic curves, comparing the size of different values is significantly more difficult to accomplish. As such, the dissertation will use both dissimilarity and entropy: dissimilarity primarily for two-group comparisons, entropy when multiple groups are included in the statistic.

Remember as well that to calculate H , every subunit's E must be calculated first ². This provides an ancillary benefit: unlike the index of dissimilarity H also offers

² Unfortunately, this makes H an unstable measure of dissimilarity when analyzing a discontinuous surface (a methodological concern introduced to the sociological literature on segregation for the first time in this dissertation). Discontinuities in a surface should only be able to segregate the total

researchers insight into *where* a population is especially diverse (a high E subunit) or homogenous (a low E subunit) and thus worthy of further analysis. Because dissimilarity is an index and not a score, it offers no such meaningful subunit value. Return again to the hypothetical three region city described above. To an outside observer, it is clear that the third region is the “most diverse.” However, the index of dissimilarity has no related index or score to identify which subunits are more or less diverse than others. The entropy score of each region, however, would do so and indeed does: the three group diversity for regions one and two is 0.50; meanwhile, region three has an E of 0.94.

Exposure

While evenness, and more specifically, dissimilarity, is still the primary factor used to measure segregation in the research literature, exposure/interaction is the most common second component of segregation used by researchers. Unlike evenness where multiple alternative measures are used by authors, exposure is widely measured using P^* , a measure often attributed to Lieberson (1981). P^* More specifically, exposure can be

surface’s distribution of two entities from each other. However, because changes in areas that are other homogenous or near-homogenous have large impacts on the entropy score than those areas that are highly diverse, discontinuities can appear to have an integrative impact on the surface in question, even though the space is less integrated than it would be without those discontinuities. An index that standardizes the subunit’s population before performing the logarithmic transformation may avoid that concern. Future projects should explore the impact of that instability and the standardized entropy score.

measured either as *isolation* by measuring xPx or as *exposure* by measuring xPy . xPx , or isolation, is:

$$xPx = \sum_{i=1}^n \left[\left(\frac{w_i}{W} \right) * \left(\frac{w_i}{t_i} \right) \right]$$

where w_i is the white population in a given area, W is the total white population in the city, and t_i is the total population of all races in that same given area. Isolation, then, reports the percentage of the population that is white in an areal unit (tract/neighborhood) for the typical white resident of the city. Exposure, by extension, replaces w_i in the second part of the equation with a different racial group to measure the percentage of the population that is not white in an areal unit for the typical white resident of the city. More formally, white exposure to black residents is calculated using the following formula:

$$xPx = \sum_{i=1}^n \left[\left(\frac{w_i}{W} \right) * \left(\frac{b_i}{t_i} \right) \right]$$

By replacing w_i with b_i , or another racial group, we can calculate the exposure or isolation of any racial group(s) of interest to the researcher.

Why Space matters: MAUP

Researchers interested in the spatial dynamics of segregation invoke two common concerns to highlight the potential inaccuracy of aspatial measures of segregation: the modifiable areal unit problem (or MAUP) and the checkerboard problem. While this

dissertation focuses less on these specific problems and more on novel spatial aspects of segregation that have previously gone unexplored due to the incomplete integration of spatial analysis and research into sociological work on segregation, it is worth discussing these two concerns in some depth to emphasize the value of spatial analysis of racial residential segregation in the urban environment.

MAUP was first discussed in detail by Openshaw and Taylor (1981) and focuses on the importance of scale when measuring a distribution across spatial units. In short, the size of an area's subunits can have an effect on any index of that area's spatial distribution of a variable, and not necessarily in a predictable fashion (Wong 1996; Downey 2006). Sociologically, most analyses of the effect of MAUP have compared census tracts to census blocks or blockgroups (Hipp 2007; Iceland and Steinmetz 2003) and found conflicting results. While Iceland and Steinmetz argue that the census block group and tract lead to insubstantial changes in measures of segregation in the United States, Hipp finds that the scales used can dramatically affect the relationship between crime and segregation in metropolitan areas.

The most obvious answer to MAUP is to identify and use a theoretically and/or conceptually meaningful areal unit to measure a spatial unit. If, for example, we are interested in racial segregation between multiple cities in a region, MAUP is not a concern because the city is a definable and concrete spatial unit. There would be no reason to merge multiple cities in the region together or to split single cities into multiple smaller units. However, when dealing with segregation internally to a city, the theoretically

meaningful unit of the neighborhood is not easily defined (Guest and Lee 1984, Grannis), and thus MAUP is a significant problem for such works. Lee and colleagues (2008) propose using a segregation profile of a city to mitigate MAUP's potential biases by recording segregation at multiple levels of geography. Unfortunately, while their efforts are a significant move forward towards a spatially integrated measurement of segregation, it still relies on faulty spatial assumptions about what best is a proxy for a neighborhood.

Clustering: More than just the Checkerboard Problem

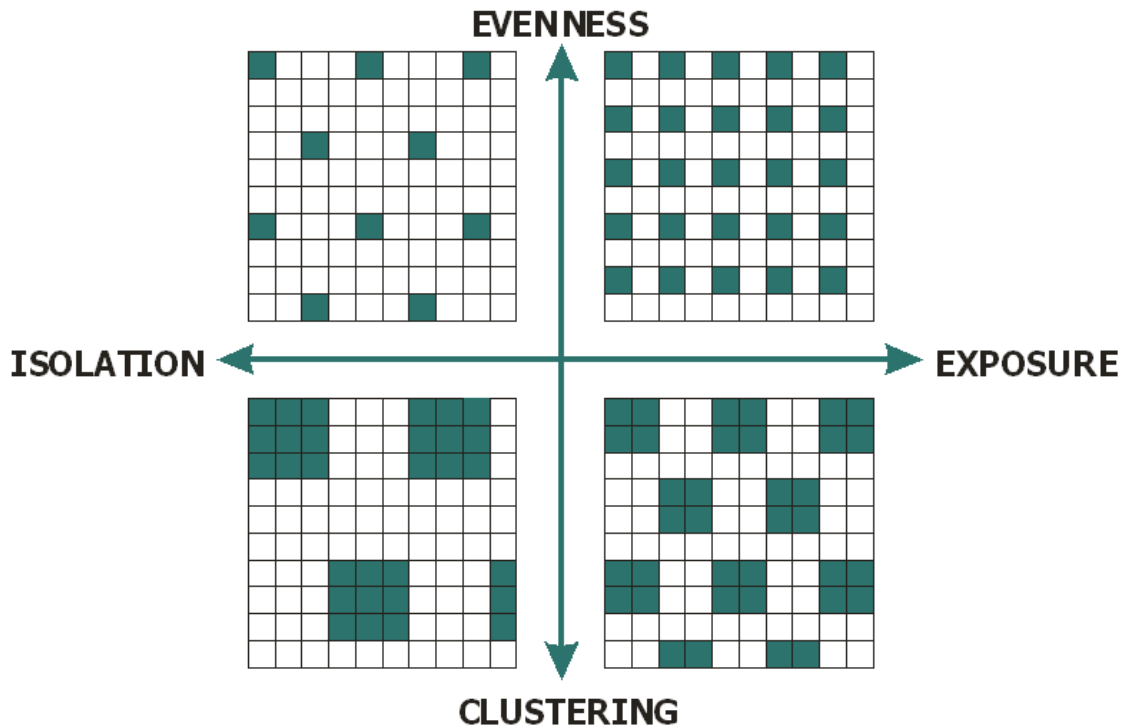
In a methodological piece incorporating space into measures of evenness and exposure, Reardon and O'Sullivan argue that such efforts make clustering an anachronism that does not warrant study:

The distinction between aspatial 'evenness' and spatial 'clustering', however, is an artifact of the reliance on spatial subareas (e.g., census tracts) at some chosen geographical scale of aggregation. Evenness, in Massey and Denton's formulation, refers to the degree to which members of different groups are over- and under-represented in different subareas relative to their overall proportions in the population. Clustering refers to the proximity of subareas with similar group proportions to one another. However, evenness at one level of aggregation (say census tracts), is clearly strongly related to clustering at a lower level of aggregation (say block groups), since tracts where a minority group is over-

represented will tend to be ‘clusters’ of block groups where the minority population is over-represented. Unless subarea boundaries correspond to meaningful social boundaries, the distinction between ‘evenness’ and ‘clustering’ is thus arbitrary. (2004; 125)

Reardon and O’Sullivan’s critique assumes that the methodological means of analyzing clustering relies on data that is flawed in two ways. First, that the subarea boundaries are not socially meaningful—an argument that appears valid when using census tracts or block groups. One cannot help but wonder, then, how their preferred method of creating concentric rings to approximate a “local environment” or “egocentric neighborhood” does not fail by this same regard: such rings disregard socially meaningful boundaries and are as prone to inaccuracy in depicting a social space as a less geometrically simple “local environment” such as a census tract. In effect, they criticize clustering as simply an after-effect of MAUP and then assume that a concentric ring is an improvement over the census tract as an areal unit to resolve MAUP. Second, they argue that clustering is simply an effect of unevenness—or, that a measure of evenness that incorporates space will also incorporate clustering. This argument follows naturally from the checkerboard problem, identified early on by white (1983) and Morrill (1991) who both argue for spatial adjustments to the index of dissimilarity to account for the checkerboard problem (for more recent advances to those efforts, see Wong 2005) The checkerboard problem is illustrated below in Figure 2.1 as shown in Reardon and O’Sullivan’s work (2004). In sum, it shows that aspatial measures of evenness would be unable to identify a difference between any of the checkerboards shown below.

Figure 2.1. Example of Checkerboard Problem



From Reardon and O'Sullivan (2004)

Most of the work that has recognized the impact of the checkerboard problem on traditional measures of segregation has asserted that spatial adjustments to the index of dissimilarity can overcome the problem. That may be true methodologically, but a conceptually misleading approach. First, if a researcher is confident enough to assert that one's areal units—be they census tracts, census block groups, concentric rings that are “local environments” or NIS neighborhoods are accurate proxies for neighborhoods, they cannot adjudicate easily between whether or not the value of spatially adjusted dissimilarity is high or low due to clustering or high or low evenness. In other words, a

city with low clustering but high aspatial dissimilarity might have the same spatially adjusted dissimilarity as a city with highly clustered but only slightly uneven neighborhoods. In addition, one of the reasons why the index of dissimilarity is often used in research is the ease with which it can be interpreted as the number of people from one racial group that would have to move to create a completely even urban environment. Unfortunately, spatial adjustments to that index negate that definition of dissimilarity.

Clustering matters both methodologically, but also conceptually. To make things even more conceptually confusing, while Reardon and O'Sullivan argue that clustering is the inverse of evenness (2004) and separate from exposure, Brown and Chung (2005) argue that clustering is not related to evenness but rather is the inverse of exposure. Fortunately, research both within and outside of the United States has shown instead that a spatial interpretation of clustering is not only a valid measure of residential segregation, but adds an important layer of detail not otherwise available using traditional measures—even those with spatial adjustments added to them (Brown and Chung 2005). This research has used Anselin's local Moran's I (1992) to identify where clusters exist within a given space.

Much like Massey and Denton (1988), I prefer to continue to use dissimilarity and entropy without their spatial adjustments as in significant part due to its continued and historical use in sociology. In addition, I do not use Moran's I to measure clustering because it is a vector based approach to spatial segregation. This dissertation is an illustration of the value of moving social science uses of spatial analysis away from

discrete vector map techniques to continuous raster techniques that provide for both novel means of measuring and analyzing traditional sociological concerns (Downey 2006), but also novel research questions about those same sociological interests, such as racial clustering and segregation. Below, I discuss the spatial methods I use and their advantages.

GIS methodologies

Raster vs. vector

Spatial data can be organized via two means: vector and raster. Vector maps and techniques are based in polygons that represent actual objects in space and are the more intuitive and common form of mapping used by social scientists (Downey 2006). Vector data use X and Y coordinates to define the location of polygons, line, and point data. For example, each census block would be a polygon in a vector map of Philadelphia, each railroad line would be stored as a line, and the location of a building or a fire hydrant would be represented, most commonly, by point data. Vector maps appear similar to a standard map on paper. Each given point or line or polygon can contain multiple variables.

Raster maps are a cell based spatial dataset. That is, while vector maps are based on the exact representation of multiple different types and shapes of data, raster maps instead take a given area and overlay a lattice of square grids over that area. Each grid

cell is assigned a value for a single variable (population, altitude, type of vegetation, etc.) that dominates that grid cell. Each raster dataset can only have a single variable, though multiple raster datasets can interact as long as the raster cells are defined as the same size and location in both datasets.

While vector maps may appear at first to be the better form of mapping for social space, raster based approaches actually provide for greater opportunity to fully integrate space into sociological research (see Downey 2006, for a very simple example of raster's greater flexibility and power). Next, I describe one problem with the most common means of measuring distance between populations using a vector dataset and how raster datasets can mitigate that problem.

Spatial Inaccuracies: Moving Beyond the Centroid Approach

Many, if not all, of the hypothetical cities used to demonstrate the impact of MAUP or the checkerboard problem are grids of cells of equal size and equal shape. As such, the theoretical problems are more easily illuminated than by using real city blocks that are often of widely varying size and shape. Unfortunately, to date, such widely varying size and shape is generally ignored in the GIS methods used to measure the urban environment and residential segregation.

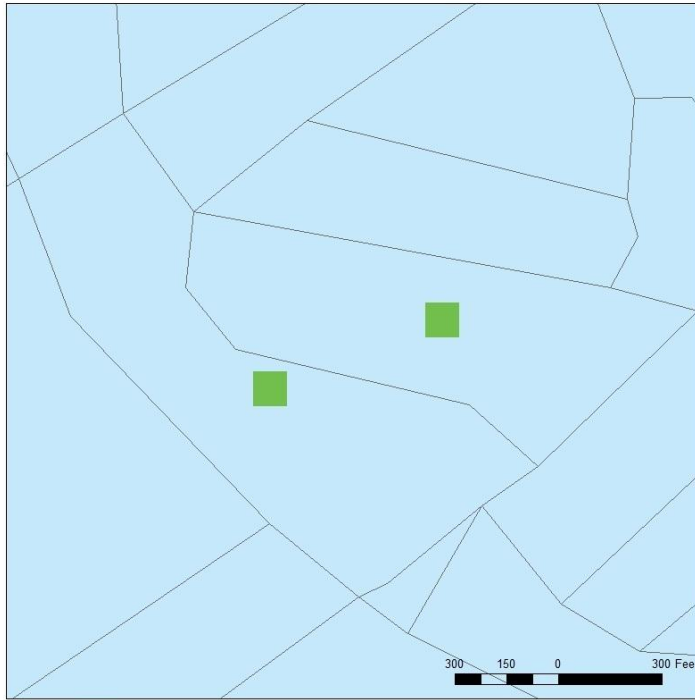
Census data commonly used by sociologists to study residential segregation is aggregated to the census block, block group, or tract level. In general, when a vector such

as a census block needs to be converted to point data (as is a necessary step in kernel density analysis), researchers identify the centroid of the vector polygon and use that as the point data as the input for the density analysis. When we imagine cities as consisting of grids of neighborhoods or blocks, using the centroid of each block makes intuitive sense. Unfortunately, census blocks are not shaped as equal sized or equal shaped polygons. Without even more local information about the size and location of specific residences within a census block, the centroid is potentially a biased proxy for use in analyses.

An example from the Roxborough neighborhood in Philadelphia illustrates the inaccuracies that a centroid approach can add and the benefits of the solution proposed here in Figure 2.2. In Figure 2.2, the green dots identify the location of the centroids of these two census blocks. Because of the irregular shapes of both blocks, a large portion of both blocks are closer to the centroid to the left as opposed to the one on the right. Were one to use block centroids and interpolate values between them (a common approach in vector based analysis), a significant portion of such irregular blocks would be misidentified as closer to the wrong block's centroid.

This example also highlights the problem of using a checkerboard as city approach to theorizing about spatial measures of segregation. While helpful in identifying the impact of the checkerboard problem or hypothesizing about the value of different spatial adjustments to traditional aspatial indices of segregation, the checkerboard is a hypothetical rarely seen outside of the central areas of cities. This may help explain why

Figure 2.2. Example of Centroids from Roxborough, Philadelphia



efforts to incorporate GIS have rarely considered the varied topologies present in cities: when the hypothetical space used to theorize about a city's segregation is overly simple, the unevenness of actual space that make centroids a potentially biased method of creating a smooth density map are obscured by the methodological and theoretical work based on the city as checkerboard.

Fortunately, raster techniques make the centroid an unnecessary part of doing density analyses such as those involved in measuring and analyzing residential segregation. Instead, a researcher can assign each raster cell in a polygon that falls in a polygon a share of that polygon's total population so that the total population of a given polygon is split evenly across each cell that lies mostly inside that polygon. This does

make the assumption that the population within a census block is evenly distributed across the entire block. While this may be inaccurate, it is a significant improvement over the misattribution that occurs when using centroids. Substantively, as well, this is a reasonable assumption. While a block may be unevenly populated, possibly because one part is houses while another part is a large apartment building, few people are likely to make such a highly localized distinction when discussing where neighborhoods start or stop or when drawing a cognitive map around a “white” neighborhood or a “black neighborhood.”

Edge Effects

One difficulty common to spatial analysis is how to best approach the boundaries of a given mapped space. That is, while this dissertation focuses solely on boundaries between neighborhoods inside of the city of Philadelphia, residents in Philadelphia are not necessarily constrained by the city limits. In fact, the mass transit system of Philadelphia is actually a regional system and parts of its system that are commonly used for intra-Philadelphia travel extend beyond the borders of Philadelphia themselves. While previous work using GIS in the social sciences has truncated the metropolitan space (Lee et al. 2008; Reardon et al. 2009) to exclude those parts of a metropolitan region that are near a boundary, this truncation is neither a necessary nor an ideal approach to edge effects. While it may not have had significant effects on their topic of interest, truncation nonetheless provides a potential source of measurement biases.

The preferred method for approaching edge effects is to extend the spatial analysis beyond the borders of the physical space under study (Bailey and Gatrell, 1995; Cowling and Hall 1996; Watts 2007). In this dissertation, I include block groups from each of the counties surrounding Philadelphia in both New Jersey and Pennsylvania so that truncation at the edges has no effect on the area of interest. I use block groups instead of blocks for areas outside of Philadelphia for ease of data management and because these areas are included predominantly to limit edge effects and do not need to be as precisely measured as the areas of interest inside the City of Philadelphia.

Raster smoothing

Much like other forms of visual representations of statistics, raster maps can often appear to have sudden changes and shifts across space. Similar to incorporating an interpolating spline or a “moving average” in a graph with noisy data, raster maps can be smoothed to better model the primary change across a space that may be obscured by noisy data. Kernel estimation (or kernel density analysis) was developed to obtain a smooth estimate of a probability density from an observed sample (Bailey and Gatrell 1995). In the case of a census where the entire population has been identified, kernel density analysis can be interpreted as a form of data smoothing as well.

In a perfectly euclidean space—that is, a space in which the direction in which one travels has no effect on how easy or difficult such travel is—the smoothing technique I use assigns to each cell the weighted average population count of that cell and its

surrounding cells. Figure 2.3 shows a basic example of this approach. This smoothing technique has the advantage of recreating the Gaussian distribution, the distribution that White (1983) argues is the most appropriate for measuring the spatial scale of segregation. This approach is empirically identical to a kernel density analysis but does not use the kernel density tool available in ArcGIS. In mathematical terms, Euclidean kernel density analysis is defined as:

$$\hat{\lambda}(s) = \sum_{i=1}^n (1/\tau^2) k\left(\frac{s - s_i}{\tau}\right)$$

Where $k(i)$ is the bivariate probability density function that is symmetric about the origin, τ is the bandwidth of a circle surrounding s in which any points (in this case, people of a given race) contribute to the kernel's estimate. One other advantage of this smoothing technique is the ease with which one can control the distance of the effect: with each iteration the smoothing reaches 50m (one cell) further than previously. More iterations allows for more smoothing and one can compare across different scales of spatial smoothing or by identifying a theoretically or empirically valid distance.

My smoothing technique is similar to that used by Lee and colleagues (2008) with one substantial difference. Lee and colleagues use pycnophylactic, or mass-preserving, smoothing as recommended by Tobler (1979)³. This method assigns each grid cell the

³ It is useful here to note that their pycnophylactic smoothing had no substantial effect on their findings about the segregation profiles of different cities. In large part this is because using smoothing before using a kernel density approach will have limited value if one expects the kernel's bandwidth to

average of its surrounding cells adjusted to maintain observed block-level counts (hence “mass-preserving”). That adjustment to preserve the “mass” of a census block, is not a necessary component of smoothing approaches and, in fact, may, in some hypothetical situations, create an inaccurate measure of the population diversity in a given area.

Imagine a group of 9 blocks in a 3x3 grid in which the one block in the middle includes 10 black residents and 0 white residents. The other 8 blocks have 50 white residents and 5 black residents each, for a total of 400 white residents and 40 black residents in those blocks. With pycnophylactic smoothing, every grid cell inside the middle block would continue to be 100% black even though each block face would share a street with a largely white population. This hypothetical example is at a logical extreme, but highlights the fact that any given block face's diversity is affected not only by its internal level of diversity within the block, but also its neighboring block faces and blocks. Mass-preserving, while a computationally compelling component of a smoothing function, is conceptually misleading and unnecessary.

routinely extend beyond the borders of any given block. Census blocks, however, are rarely as large as the kernels used by Lee and colleagues. In other words, Lee and colleagues effectively use forms of smoothing (kernel density and pycnophylactic) twice on one map. It should be no surprise that whether or not one smooths a soon-to-be smoothed surface has no effect on the ultimate outcome.

Figure 2.3. Hypothetical Euclidean Kernel Density Smoothing

0	0	0
0	63	0
0	0	0
7	7	7
7	7	7
7	7	7

Non-euclidean smoothing

Social space, however, is not euclidean. Different physical attributes of a space can dramatically affect the ease of interaction in that space. One brief example should suffice for this section of the dissertation. On one hand, people who live along a small, tertiary street are likely to interact and be exposed to each other as living in proximity, even if they live a number of blocks away from each other, as they may frequently walk along the same sidewalks, frequent the same shops and restaurants, etc (Grannis 2009). On the other hand, people living across an interstate highway from each other may be physically as close as the residents described above, but are much less likely to interact.

To date, while some have shown the impact of physical barriers (see also Ananat 2011) on residential segregation, no one has attempted to map and visually represent such barriers. Fortunately, representing these physical barriers is a conceptually simple task. Imagine that the populations that are being smoothed in the above figure are, in fact, a liquid slowly spreading evenly across a perfectly smooth and level field. Physical barriers to residential interaction in this extended metaphor can be seen as levels of particularly high or low friction on that previously level space. A park, where people may be more likely to share the social space and interact (see Jacobs 1961; or Anderson 2011), would be a low friction area, through which that liquid would move more quickly than across a level field. Large highways or rivers would have high levels of friction that slow the movement and interaction of residents across that social space. Mathematically, we return to the equation for Euclidean kernel density analysis and change the bandwidth (τ) to vary dependent on the “friction” at each grid cell:

$$\sum_{i=1}^n (1/\tau^*)^2 k\left(\frac{\mathbf{s} - \mathbf{s}_i}{\tau^*}\right)$$

The only change is that τ is now τ^* , in which the bandwidth is not equal regardless of direction but instead is a function of a given friction (or cost) function of the space. As Bailey and Gatrell (1995) note, the kernel estimate is “just a more sophisticated version of the weighted moving average scheme” (161). A non-Euclidean kernel density analysis can be seen as simply a weighted moving average that changes shape dependent on a second variable of interest, in this dissertation, that second variable is physical barriers to

social interaction. In other studies, major roads may provide advantages instead of problems, or the spread of pollution may be related to elevation at a given point instead of to social space such as parks or vacant lots.

Figure 2.4 shows the computational process behind one iteration of the same hypothetical population as in Figure 2.4 previously, except it also includes an area of high friction in which it is twice as hard to smooth the population. Compared to the previous figure, the friction levels create a more variegated space and involve multiple steps to compute. First, the friction of each cell is changed into a “receptiveness” based on the reciprocal of the friction in that cell. Importantly, that friction only impacts the smoothing *if there are multiple friction values* within the nine cell block that surrounds and includes the original cell of interest. If every cell in that 3x3 area has the same friction—even if that value is not set to 1—the resulting smoothing will be Euclidean. Next, the receptiveness totals are added into a “total receptiveness” and divided into proportions for each cell that then are used to calculate what population each cell receives from the original population of the middle cell. Whereas in the first figure, each of the surrounding areas had the same population of seven individuals after a kernel density analysis, in the new figure, the friction led to noticeable differences. Cells with double the friction had only 4.5 individuals assigned to it, while those cells with the same friction value as the original cell had 9 total residents. While this may appear to be a flaw in the method (that cells with no significant friction end up with additional residents instead of the same value as they would have received in a Euclidean smoothing), it picks up on an important

Figure 2.4. Hypothetical Non-Euclidean Kernel Density Smoothing

Original Values:

0 (friction = 1)	0 (friction = 1)	0 (friction = 1)
0 (friction = 1)	63(friction = 1)	0 (friction = 2)
0 (friction = 2)	0 (friction = 2)	0 (friction = 2)

Receptiveness:

1	1	1
1	1	$\frac{1}{2}$
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$

Proportion of Total Received:

$\frac{1}{7}$	$\frac{1}{7}$	$\frac{1}{7}$
$\frac{1}{7}$	$\frac{1}{7}$	$\frac{1}{14}$
$\frac{1}{14}$	$\frac{1}{14}$	$\frac{1}{14}$

End Value:

9	9	9
9	9	4.5
4.5	4.5	4.5

insight into social isolation. Imagine a city block that is next to a major boundary to its east, west, and south. As such, its residents do not cross the boundary (or do so infrequently) in those direction and therefore are more likely than residents of a block that is not next to major boundaries to move north and interact with their neighbors in that direction. In other words, by being up against a boundary in one direction, it makes one more likely to interact with and be associated with those residents who live in the opposite directions. Likewise, being near an area that is attractive (low friction) would make one more likely to interact with people in that direction to the detriment of potential interaction and integration to other directions.

Defining Barriers and their Friction

Beneficially, a researcher can control how much friction a given barrier or pathway does or does not create for the spread of residents across a social space. Ideally, such efforts would be informed by empirical observation of a given space. However, because this method is novel, such observations have not occurred and would greatly benefit these efforts. Fortunately, it is simple to create multiple possible levels of friction and compare the results to see if the relative level of friction assigned to different barriers and pathways affects the overall representation of racial residential boundaries and segregation. For this paper, I tested the impact of six different friction weights at barriers to provide a range of possible impacts of barriers. The six frictions tested were 1.1 (barriers have 10% more friction than residential spaces), 1.25, 1.5, 2, 10, 1000. The first

three frictions were selected to conservatively estimate the impact of friction on residential segregation, as barriers would be easily “permeable” in a smoothing calculation. The double strength barriers were selected due to the conceptual ease of interpreting that impact. The friction value of ten was selected to make barriers substantially difficult to “cross” with regard to residential segregation, but not completely impassable. Finally, the value of 1000 was included to simulate nearly impassable barriers, as many highways or railroads clearly demarcate the boundary between barriers. For example, the Schuylkill River is a wide river with few bridges. As such, it is clearly a barrier to integration: that one side of the river is largely white while the other side is largely black (as is the case when comparing the neighborhoods of Fairmount on the east bank of the river to Mantua on the west bank) should have no significant impact on the level of segregation reported in either neighborhood. To put these friction values into perspective, imagine a hypothetical neighborhood that is 100% white and consists of detached single family houses. Now, focus on one home in that neighborhood that is near a barrier on the edge of that white neighborhood. When that barrier has a friction value that is double that of non-barriers, it is as though the single family household is twice as likely to consider residents on the other side of the barrier as non-neighbors compared to those on their own side of the boundary. As long as there are at least a small number of black residents on the other side of the barrier, the white family would consider them as part of their “egocentric” neighborhood. When the barrier’s friction is ten times that of non-barriers, it would mean that the black residents on the other side of the barrier would have to be ten times more densely populated to impact that white family’s “egocentric

neighborhood.” In effect, rowhomes across a barrier, with their smaller, more dense footprint, or small brownstones with multiple units, would be equal to detached, single-family households that aren’t across a barrier. When the friction level is set to 1000, it is as though the barrier is nearly a wall: only high rise apartments across that barrier would impact that white family’s “egocentric” neighborhood.

Unfortunately, there is no research on the proper “strength” of friction on residential neighborhoods and formation. Grannis’ work (2009; 1998) hints that the nearly impassable simulation may be the most accurate, albeit with the caveat that tertiary streets that cross major roads do provide for more social integration compared to areas of major roads without smaller cross streets. Meanwhile, studies of crime patterns have shown that physical barriers have small to no impact on crime “trips” in The Hague, but The Hague is a geographically compact city with few barriers (Peeters and Elffers 2010). On the other hand, Clare and colleagues (2009) show that large barriers, like a river, did impact crime spread. In sum, this dissertation cannot identify the correct friction to assign barriers, but can show how much friction barriers “need” in order to impact the observed racial residential segregation of the city. Future work should study the actual flow of individuals across boundaries in order to provide empirical evidence of the correct level of friction to assign to barriers. The chapters that incorporate non-euclidean smoothing report results from only the 2, 10, and 1000 friction value results. In sum, the smaller barrier values have very small impacts, neither on indices of residential segregation in the city nor on the local patterns of segregation, and any impacts from those smaller barrier

results are captured by the results from the smoothing analysis in which barriers have double the friction of non-barriers.

In addition, I define what parts of the geography of the city are and are not barriers with regard to residential segregation. Following Grannis (2009), I defined primary and secondary roads as barriers. Primary roads are categorized by the Census Bureau as those roads that are either interstate highways, toll highways, or regionally important roads such as county highways that often are multi-lane. Examples in Philadelphia range from interstate 95 or 76 to multi-lane roads such as Girard Avenue or Broad Street to locally important single-lane roads such as Wissahickon Avenue. While Grannis instead focuses on the importance of tertiary streets and their crossing primary and secondary roads, my interest is in borders—while tertiary streets do cross major roads and lead to enhanced interaction, that enhancement is only in comparison to areas of major roads where tertiary streets do not provide crossings. All railroad tracks are similarly designated as potential barriers, as are any waterways for similar reasons.

Another potential barrier that may impact levels of residential segregation is non-residential land use. Non-residential land use can be the result of zoning for only commercial or industrial spaces (such as the North Philadelphia Airport, the commercial blocks on West Market Street, or major institutions such as large schools or hospitals), or because of residential vacancy (roughly 40,000 parcels are vacant). Unfortunately, this dissertation does not look at the parcel level impact of vacancy, and instead identifies non-residential spaces as any census block which has a population of zero. Some of these

non-residential blocks may contain major institutions such as a neighborhood school or a thriving retail block that can act as a local space of heightened cross-racial interaction (Anderson 2011). While those particular locations may provide for improved interaction, they still can provide an important social and spatial barrier: living north or south of a major institution may mean living in two very different neighborhoods. For example, just north of the Reading Terminal Market is Chinatown, while directly south of the market and the shopping mall next to it is an area known either as Washington Square West or Center City East. Chinatown is a largely immigrant and Asian neighborhood, while Washington Square West is a more affluent, majority white neighborhood.

Finally, partly as a test of the theory that some spaces can have an integrative impact on the local area, I treat state and city owned parks as having lower friction levels than residential spaces, proportional to the weight given to barriers such as major roads (if a road has twice the friction of a residential area, a park has one half the friction of that same residential area). Here I theorize that living near a park can be an important part of deciding to live in that location. As such, the park may act as a pull for residents, regardless of direction, and thus may act as an anchor space and one that could provide for improved integration in the local area. In Philadelphia, however, the majority of the park spaces owned and operated by government entities either include a waterway in the middle of it (such as Fairmount Park and the Schuylkill River), or are too small to have a significant impact on my findings.

Chapter 3:

When Integrated is not Integration:

Mapping Intra-Neighborhood Racial Residential Segregation

We know from existing research that individuals choose where to live on a number of neighborhood factors such as school quality, housing cost, and job access. Local levels of integration, as a signaling mechanism for neighborhood quality, can strongly affect that decision-making process, both on the part of the resident and realty agent (Farley et al. 1978; Charles 2006; Emerson, Choi and Yancey 2008; Yinger 1986, 1995). Prospective residents, in short, consider white neighborhoods to be of a higher quality; living in a black identified neighborhood is associated with lower housing prices (Flippen 2004), higher rates of subprime mortgages (Rugh and Massey 2010) and violent crime (Krivo and Peterson 2010), it is possible that such relationships could also work at an even lower levels of geography. Being on the “black” side of a neighborhood, if such a thing exists, may be related to those same negative outcomes. Unfortunately, while previous studies of residential segregation have provided valuable insights into the extent of racial inequality and its effects, they have left unanswered a basic question at the meso-level of analysis: how integrated are neighborhoods internally? Citywide indexes of segregation use neighborhoods as whole entities, implying that the internal structure of a neighborhood is either uniform or unimportant in modeling urban segregation.

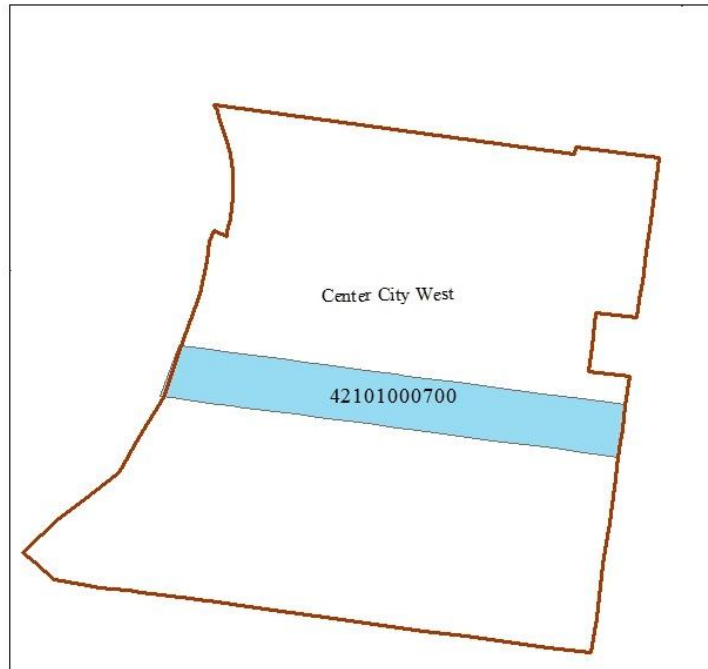
However, if integration does not extend within the neighborhood, then that has serious implications for how much positive benefit living in an ‘integrated’ neighborhood provides individuals (Hipp 2007; Charles 2003). Hipp (2007) shows that *between* and *within* neighborhood effects can illuminate different micro and meso level effects of context on crime rates. Similarly, the spillover effects of assisted housing development on housing values varies within an urban environment dependent on localized effects (Koschinsky 2009). That same study, however, notes that the potential negative effects could be mitigated “through proactive policies such as dispersion, good neighbor guidelines...” (343). In other words, not only are the relative effects of public policy efforts often related to meso-level contexts, but also those contextual variations can be affected directly by public policy. Unfortunately, no similar effort has studied how racial segregation does or does not persist *within* neighborhoods as a way to identify local areas of contestation that may be uniquely fruitful locations to target for policy interventions. This chapter explores the internal structure of integrated neighborhoods and examines whether integration persists at the sub-neighborhood level, both temporally and spatially. The assumption that “integrated neighborhoods” are consistently integrated internally has gone unchallenged in sociological research for two practical reasons. First, sociologists have relied on the census tract as proxies for neighborhoods, and exploring its internal dynamics would only compound and exaggerate the measurement error introduced by relying on that proxy in the first place. Second, even if we accept the tract as a good approximation of an urban neighborhood, many census tracts contain too few smaller areal units to adequately measure the internal degree of segregation. Some urban census

tracts, for instance, contain only one census block group, traditionally equal to eight blocks worth of geography. As a social space, that is too small to meaningfully index segregation internally. For an example of the inaccuracies possible when using a census tract as a local neighborhood, Figure 3.1 shows the borders of a single tract (421010700) and the NIS neighborhood¹ that includes that tract. The tract extends from Broad Street on the East to 23rd on the West and from Chestnut Street to the North to Walnut Street to the South; only one single-lane street runs between Walnut and Chestnut from west to east. In other words, that census tract, if one were to use it as a “neighborhood” consists of two rows of nine blocks. In reality, residents are not constrained by either Chestnut or Walnut, rather, Chestnut and Walnut are the two main commercial streets that anchor a single neighborhood (Center City West) extending north one block to Market and south at least four blocks yielding a 6x9 grid of blocks that more accurately produce a potential “neighborhood.”

To date, scholars of segregation in the United States that have studied either the micro-level interactions and decisions that lead individuals to perpetuate segregation (Charles 2007; Krysan 2002; Crowder and South 2005; Krysan 2002; Krysan, Farley and

¹ As described in the Data and Methods chapter, NIS neighborhoods are locally defined, historically and socially relevant neighborhood boundaries identified in the early 1990s by urban planners, city officials, and academic researchers to better identify Philadelphia’s social geography compared to census tracts. There are 69 stable NIS neighborhoods compared to over 350 census tracts.

Figure 3.1. Example of Census Tracts vs. NIS Neighborhood Boundaries



Couper 2008) or measures of citywide inequality and segregation (Timberlake and Iceland 2007; Rugh and Massey 2010) have done so without incorporating space into their analyses. Geographers have long argued that the commonly used aspatial measures of inequality and segregation can obscure local variation in the clustering of segregated neighborhoods, i.e the “checkerboard problem” (Reardon and Sullivan 2004; (Wong 1993; 2005; Morrill 1991). Imagine two cities in which half of the neighborhoods are 100% white and the other half are 100% black. In City A, all of the white neighborhoods are clustered together in the northern half of the city while the southern half of the city is

entirely black. In City B, the neighborhoods are dispersed amongst each other, like a checkerboard. Both cities are equally and completely segregated based on traditional measures of evenness such as the index of dissimilarity and the entropy index.

Researchers offer three solutions to that problem: 1) adjustments to these aspatial measures of segregation to incorporate spatial clustering (Wong 2005; Reardon and O'Sullivan 2004); 2) the incorporation of measures of clustering as additional and separate measure of a city's racial residential segregation (Massey and Denton 1988); 3) the replacement of neighborhood proxies with distance-decay functions for residents in a metropolitan area (Lee et al. 2008).

Clustering has traditionally been overlooked in the sociological literature on residential segregation for several reasons. First, dissimilarity and/or entropy generally capture the main thrust of sociological interest in segregation: the degree to which people of different races and ethnicities live near each other. Whether or not they do so in a clustered manner appears to be a second-order question, and evenness and clustering are often highly correlated. Second, Massey and Denton (1988) used factor analysis to show that the only measure of clustering that was not also equally measuring exposure has never been used in research on segregation and inexact. Third, presenting multiple indices of segregation can lead to disagreement: is a highly clustered city that has lower dissimilarity more or less segregated than a city that exhibits less clustering but is has a higher dissimilarity index? In short, clustering is largely unexplored in sociology, and more recent efforts to adjudicate between the many possible measures of residential segregation describe it as a statistical component of evenness (Reardon and O'Sullivan

2004; Reardon and Firebaugh 2002). In this chapter, I introduce an alternative mapping technique that enhances our ability to visualize, more accurately measure, and interpret segregation that also highlights the importance of clustering as a separate, critical component of racial residential segregation that is critical to better understanding racial inequality more broadly.

If clustering is a separate component of segregation above and beyond evenness then requires a measure that is not highly correlated with standard measures of evenness. A small body of research has introduced the use of the spatial statistic Moran's I to resolve this dilemma, and to explore racial/ethnic clustering in both the United States (Brown and Chung 2006) and internationally (Lloyd, Shuttleworth, and McNair 2004; Martori, Hoberg, and Surnach 2005). Unfortunately, this use of the local Moran's I, while appealing, is a misapplication of the statistic. Moran's I is a global measure of clustering for an entire geographic area (either the city or an individual neighborhood in this chapter). Anselin (1992) demonstrates that the Global Moran's I is a sum of individual levels of clustering across all subregions, and that one can calculate a local Moran's I and evaluate the statistical significance of each I_i to identify the locations of specific clusters and whether or not they are the result of random spatial autocorrelation. Unfortunately, this use of Moran's I is an inappropriate extension of the statistic because the statistic misidentifies the null hypothesis as less than perfect dispersion/integration. In spatial analysis, spatial autocorrelation is expected. For example, hills and mountains are generally located next to other hills and mountains. The null hypothesis for Moran's I, then, is that there will be some spatial autocorrelation in any given analysis, but that such

correlation is randomly distributed. Sociologically, however, clustering of individuals into segregated areas is not the correct null hypothesis. Instead, a perfectly dispersed population with a completely integrated population is the appropriate null hypothesis for tests of whether or not segregation exists. That perfectly integrated population (a dissimilarity of .000 or a maximum entropy score), would have a statistically significant negative Moran's I value. Spatially, dispersion is a statistically unexpected phenomenon; sociologically, such dispersion is more appropriately considered the null hypothesis. Unfortunately, although the few studies that have incorporated Moran's I have advanced the literature on segregation, they have done so without considering this important aspect of the statistic.

I propose a fourth option: the use of mapping to avoid reliance on multiple, potentially contradictory indices to describe residential segregation, and to escape the misapplication of the spatial statistic, Moran's I. I examine the internal clustering of residents across two case studies of the most “integrated” neighborhoods in Philadelphia, testing the degree to which neighborhoods are integrated at the micro-level (the block). The mapping techniques used here provide further benefit beyond reintroducing clustering into the sociological consideration of racial segregation. Mapping also provides an opportunity to pursue a visual sociology of segregation instead of a quantitative sociology of segregation. As the case studies of West Mount Airy and University City show, the visual representation of segregation accomplishes the additional benefit of being more easily presented and interpreted by non-experts. The efforts to create improved quantitative measures of residential inequality has had the

unfortunate byproduct of making these measures increasingly hard to interpret, analyze, or use by those not trained in both advanced social statistics and spatial analysis. However, residential integration is a critical aspect of urban planning and politics and in order for innovative sociological research in this field to both advance knowledge but also provide a social benefit, it should be accessible to urban planners and policy makers, many of whom may not understand the nuances of statistical measures of segregation. To tweak the cliché: a map is worth a thousand numbers.

Data and Methods

Data for this chapter are from the 1990, 2000 and 2010 census. Data for all census blocks in Philadelphia were spatially joined in ArcGIS 10, with the shapefile for the 69 Philadelphia neighborhoods from the NIS. The resulting population data from that merge were compared to the NIS' own merge of census data and their geographies to ensure accuracy. It is important to note that the census does some data swapping of local blocks to protect the confidentiality of individuals. This primarily happens for blocks with few residents, but may influence my findings (Census 2007). Fortunately, the census does not swap individuals across tracts, so these moves should have little impact on the analytic results.

To create a more robust portrait of racial residential integration in Philadelphia neighborhoods, I employ two measures of evenness in my numerical analysis of internal integration: the index of dissimilarity and the entropy index for each neighborhood. The

index of dissimilarity provides the benefit of being the most commonly applied measure of segregation in sociology (Taueber and Taueber 1965; Massey and Denton 1988; Charles 2003). However, when attempting to incorporate more than two groups into the index of dissimilarity, one must either analyze multiple separate indices of dissimilarity, or must merge two group populations into one (as I do to incorporate Latinos into the black/white index of dissimilarity). On the other hand, the entropy index can easily accommodate multiple groups in one measure (see Iceland 2004), allowing the inclusion of Asians and Latinos without merging their populations with either the black or white populations in a neighborhood to test whether or not their increasing immigration into Philadelphia alters the narrative about integrated neighborhoods in Philadelphia. I also include two calculations of a traditional measure of exposure, the index of isolation, to measure black exposure to whites within each neighborhood and black exposure to all non-black residents in each neighborhood.

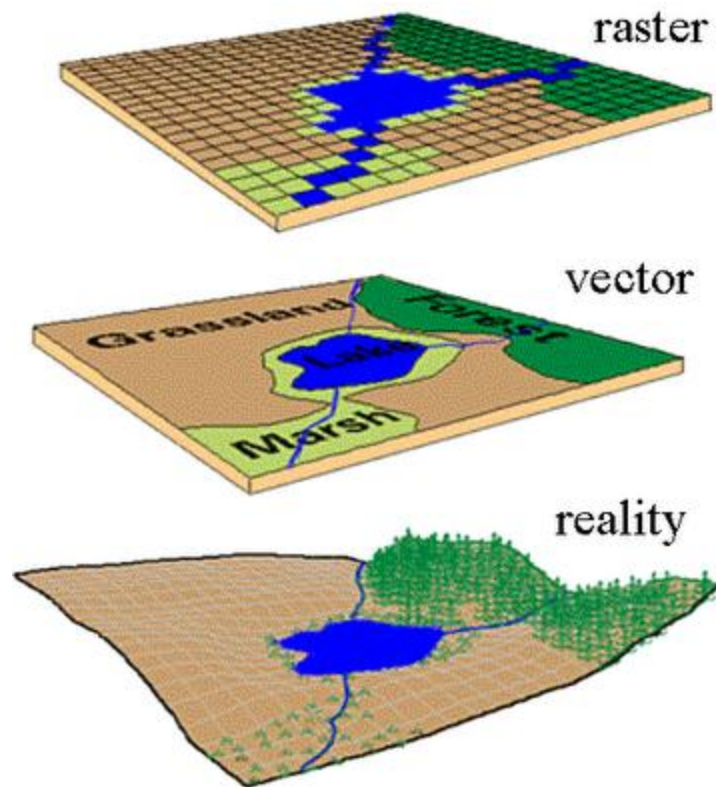
Mapping Racial Residential Clustering

Instead of relying on a statistical approach to measuring clustering, I instead use GIS mapping techniques to explore the level of clustering in Philadelphia. GIS offers a range of techniques/options for analyzing spatial relations between groups. In this dissertation, I explore one set of methods utilizing raster mapping; I argue this method exemplifies the potential of GIS for innovative research that can be easily interpreted by both social scientists as well as non-specialists. Others have used GIS for similar research

on better quantitative measurements of racial segregation (Lee et al. 2008), urban racial inequality (Downey 2007), and socioeconomic segregation (Grengs 2007). While demonstrating the value of GIS for improving our accuracy in measuring and modeling traditional research interests, I use a more spatially-based approach than previous researchers: rather than viewing GIS as a tool to create better quantitative measures sociologists have long studied, I approach it as a way to introduce novel approaches to traditional research questions.

GIS divides maps into two categories: vector and raster maps. Figure 3.2 is a commonly used illustration of how vector and raster maps approach representing space. Vector maps are polygons and lines of varying sizes and shapes, each of which holds values for different variables of interest. A map of the neighborhoods of Philadelphia is an example of a vector map. Raster maps superimpose a grid on a geographic area and gives each grid cell a value depending on one's interest. While Raster maps may appear less accurate than vector maps, using sufficiently small grid cells so that every possible vector polygon would include at least one full raster cell minimizes any possible inaccuracies created. Further, raster maps offer a wider range of possibilities within GIS for accurately measuring social realities on a granular geographic scale (see also Grengs 2007).

Figure 3.2. Graphic Example of Raster vs. Vector Mapping Techniques



In this chapter, I first incorporate the smoothing techniques described in Chapter Two. Data smoothing is widely used in environmental and material sciences and can also be used in the social sciences. Imagine a raster map as a flat surface. Each cell on that flat surface has a value representing the density of white residents in that local area. A second raster map has a value representing the density of black residents in that local area.

Consider those values now as a third dimension, or a height, for each cell, depending on which value the viewer is currently interested in studying. Unfortunately, such a map could have large swings in value where two blocks meet (especially if one

block is single-family houses and the next block includes a large apartment complex). Imagine, for example, three blocks in a row of equal size. One has 100 residents in apartment buildings. The middle block has 20 white residents living in detached houses. The third has 100 black residents and 5 white residents in apartment buildings much like the first block. Should we describe that middle block as significantly more integrated, even as it is surrounded by almost entirely black blocks? Such micro-level results may cloud the larger trend of those three blocks that, as a whole, have 210 black residents and only 20 white residents. Analyzing a map without using a form of data smoothing is similar to attempting to analyze a bivariate scatterplot by sight: raster smoothing plays the same role as a best-fit line in identifying trends across data points.

The hypothetical three dimensional map also highlights the importance of carefully considering the incorporation of non-residential spaces on a map of racial segregation. Non-residential blocks would appear on the map to have a height of zero, as they have population densities of zero. A large area of such spaces—often due to the existence of a commercial district, an industrial park, or a large park—would appear on the map above as a large area that lacks white residents. This would dramatically alter the visual representation of urban areas which often have significant spaces specialized for non-residential use dispersed between and within residential neighborhoods. In 1990, Philadelphia contained 16,099 total census blocks, 2,373 of which were entirely non-residential spaces. In 2000, there were a total of 17,315 blocks, 3,155 of which had no residential population.

For example, treating a park surrounded by white residents as an area with no white residents would bias a map away from recognizing that the park lies within a racial cluster. Similarly, if that same park is located between a 70% white and a 70% black area, treating it as containing neither group would present an additional problem. The park would appear to represent two distinct racial boundaries: one where the black population went 70% to 0% and then back up to 30%, creating an analytically confusing and overly complex map of racial segregation due to the inaccurate measurement of non-residential space. In later parts of the dissertation, I study how treating these areas as functionally unique compared to residential areas does or does not change the analysis of racial segregation and neighborhood boundaries. In this chapter, to focus primarily on the internal dynamics of neighborhoods, I treat both non-residential and residential blocks using the same method of data smoothing.

Conceptually, raster smoothing provides additional benefits beyond identifying trends across multiple blocks because living at different locations of a census block can lead to different experiences of integration. Imagine two individuals both living on the same census block that is 100% non-Hispanic white: one in the southern edge of the block, directly facing a predominantly black block across the street. The other individual lives on the northern side of that block, facing another 100% non-Hispanic white block. The two, while living geographically on the same block, have different block face experiences of segregation. Smoothing models that reality more accurately than treating each block as a single entity can. Smoothing also has the benefit of being a conservative estimator: the more smoothing one does, the closer one gets to a completely flat map, or,

one in which all localized racial segregation has been smoothed away. For this chapter, I use the nearest-neighbor average smoothing tool available via spatial analyst and repeat that process ten times. Repeated uses of the nearest neighbor average smoothing creates a Gaussian distribution of values and is similar to the approach used by Lee and colleagues in their work on racial segregation, without the mass-preserving component they added². In other words, I perform a biweight kernel density analysis in which the kernel has a radius of 500 meters.

² Lee and colleagues found no effect of smoothing on their final results. In part, that is because they effectively smoothed twice: first by using phonopylactic (mass-preserving) smoothing and then by taking a spatially weighted value of a local neighborhood. Taking a spatially weighted value over an entire raster map—and the biweight kernal approach they and White (1983) advocate is a Gaussian weighting—is, in reality, an alternative means to perform data smoothing. As such, it is no surprise Lee and colleague's found no effect from phonphlactic smoothing: any smoothing they performed was effectively irrelevant because their final analysis involved another smoothing process anyway (albeit without mass-preserving). Fortunately, the fact that mass-preserving smoothing had no effect on their measures provides strong evidence that mass-preserving is an unnecessary step in the process.

The Fortunes of Integrated Neighborhoods

1990: Setting a Baseline

While overall levels of segregation have decreased since reaching their apex in 1970 (Charles 2003), this does not necessarily mean that integration is becoming substantially more common nor that integrated neighborhoods are stably integrated over time (Friedman 2008). Schelling (1971, 1972) first identified the unfortunate consequence of racial differences in comfort with and desire for integrated neighborhoods: a natural progression from integration to resegregation (also see Yinger 1974). More recent efforts have shown that empirical results support Schelling's pessimistic theoretical work (Bobo and Zubrinsky 1996; Charles 2007; Bruch and Mare 2006). More recent work has expanded on Schelling's model to more accurately measure contemporary racial differences in desire for integration with the same pessimistic end result of a slide towards resegregation, albeit slower than in Schelling's original model (Bruch and Mare 2009; Van de Rijt, Siegel and Macy, 2009).

Previous sociological research strongly suggests that Philadelphia's integrated neighborhoods are more likely neighborhoods undergoing racial transition. Further supporting that hypothesis is the fact that Philadelphia has been and continues to be a hypersegregated city for its black residents (Massey and Denton 1993), implying that white Philadelphians are particularly likely to be disinclined to live in integrated neighborhoods or even stay in the city; since 1990, Philadelphia lost over 40% of its white population. Overall, Philadelphia is fundamentally a segregated city; however,

pockets of integration may remain. In particular, two neighborhoods are valuable case studies of neighborhoods with unique potential to be stably integrated over time: University City and West Mount Airy. University City has, since the mid-1990s, undergone significant gentrification buoyed primarily by the efforts of the University of Pennsylvania. Because of Penn's deep pockets and large presence in Philadelphia (Penn is Philadelphia's single largest employer), Penn has both the monetary and political power to greatly influence the local neighborhood and potentially sustain local integration via that influence. West Mount Airy, on the other hand, has a nationally recognized history as a "stably integrated" neighborhood since the 1960s. In 1959, West Mount Airy faced potential racial turnover as black residents began to move into the neighborhood. Uniquely, residents of West Mount Airy created a civic organization to support integration and convince white residents not to move because of the influx of black neighbors (Saltman 1991). Since then, West Mount Airy has maintained a sense of pride in its racial admixture and the national recognition for its identity as racially integrated since the 1960s and has received significant newspaper and academic attention because of that racial integration³. Before exploring those two locations in more depth, I first explore whether or not Philadelphia's integrated neighborhoods follow Schelling's model of racial turnover.

3 An extensive bibliography of more than 100 press articles and over 30 academic studies focused on West Mount has been compiled by the West Mount Airy Neighbors (WMAN), a local non-profit and available online at wman.goodbarry.com/LiteratureRetrieve.aspx?ID=35448

To accomplish this, I first define integration in a way that is operationalizable. I create a measure that includes any neighborhood that in 1990 has 1) either a multigroup entropy score (including all four major racial/ethnic groups) or 2) a black-white entropy score at least one standard deviation above the average for all Philadelphia's neighborhoods. Before 2000, Philadelphia had very low levels of immigration, so many integrated neighborhood contain very few residents who are neither black nor white, and thus might have low multigroup entropy scores while still integrated (West Mount Airy is a good example. In all three censuses, West Mount Airy's population was less than 5% Asian and Hispanic combined). This identifies both neighborhoods that have experienced integration because they include ethnic enclaves for new immigrants and those that do not include ethnic enclaves. Nineteen of Philadelphia's 69 neighborhoods meet at least one of those two requirements; nine of those nineteen meet both criteria, seven of the nineteen meet the requirement only when Asians and Latinos are excluded, and three meet the requirement only when Asians and Latinos are included. I exclude two neighborhoods from my sample (Hunting Park and Logan) because their entropy level reaches the criteria only due to the integration of black and Hispanic residents; the white population in both neighborhoods is below 20%. While Hispanics do not experience the same level of segregation as blacks, they are often segregated into distressed, predominantly black areas compared to whites (Massey and Denton 1993; Charles 2006; Peterson and Krivo 2010). In the end, there are 17 neighborhoods that I define as "integrated" in 1990.

Table 3.1 summarizes demographic information for the 17 “integrated” neighborhoods as well as the average results for all seventeen compared to the rest of Philadelphia, both non-integrated and average neighborhoods. It is worth noting how loosely “integrated” is defined here. East Mount Airy is about two thirds black, while Kensington is about one-third white. Nonetheless, compared to the rest of Philadelphia, these neighborhoods are substantially more integrated in terms of their total population. Internally, the story is significantly more complicated.

The last six columns in Table 3.1 are measures of internal segregation levels for each neighborhood. In each column, higher scores indicate higher levels of internal segregation. Compared to non-integrated neighborhoods, these neighborhoods have higher entropy index (columns 7 and 8) values both when we include Asians and Latinos in the calculation and when we look only at black and white residents. In other words, while the total population shares are more equitably divided, individuals in these neighborhoods are less likely to live on blocks that mirror that total population composition. The index of dissimilarity shows a similar theme (columns 9 and 10), with average D scores for integrated neighborhoods that are consistently higher than those for non-integrated neighborhoods.

These results, however, are biased by extremely segregated neighborhood like East Germantown and Fox Chase. Both have extremely low entropy index (0.21 and 0.20) and dissimilarity index values (0.38 and 0.52). This, however, is largely a byproduct of the

Table 3.1 Measures of Internal Integration for “Integrated” Neighborhoods in 1990

Neighborhood	Criteria Met	1990 Population	% White	% Black	% Asian /Latino	Entropy Index	Black/white Entropy Index	Black/ white D	Black and Hispanic/ white D	Black/white isolation	Black and Hispanic isolation from white
Cedar Park	Both	16787	29	60	10	0.42	0.56	0.76	0.74	.87	.86
Chestnut Hill	black/white	10516	55	43	2	0.61	0.69	0.82	0.81	.86	.85
East Mount Airy	black/white	18153	31	67	2	0.41	0.45	0.65	0.65	.84	.84
East Oak Lane	Both	17375	58	22	21	0.24	0.47	0.69	0.52	.64	.57
Eastwick	black/white	17000	62	34	3	0.55	0.63	0.82	0.8	.79	.78
Elmwood	black/white	29320	44	52	4	0.68	0.8	0.89	0.89	.93	.92
Fairhill	Both	31512	30	14	56	0.43	0.71	0.85	0.72	.83	.88
Fairmount	Both	20765	58	36	6	0.54	0.67	0.8	0.77	.83	.81
Fishtown	Both	19980	45	40	15	0.63	0.8	0.88	0.84	.91	.89
Gray's Ferry	Both	14048	48	50	2	0.75	0.81	0.9	0.89	.93	.92
Kensington	All Groups	17474	64	13	24	0.68	0.91	0.96	0.88	.94	.89
Olney	Both	32011	43	32	26	0.35	0.59	0.73	0.59	.79	.74
Overbrook	black/white	30024	40	57	3	0.65	0.75	0.87	0.86	.92	.91
University City	Both	17138	61	37	3	0.24	0.37	0.57	0.53	.59	.57
West Kensington	Both	15309	34	26	39	0.62	0.87	0.93	0.87	.94	.94
West Mount Airy	black/white	17434	38	60	3	0.26	0.28	0.49	0.49	.74	.74
Wynnefield	Both	19516	45	50	5	0.44	0.52	0.74	0.73	.81	.80
Integrated		20256	0.46	0.4	0.14	0.5	0.64	0.79	0.74	.83	.82
Neighborhood											
Average											
Non Integrated		23765	0.56	0.38	0.06	0.41	0.51	0.75	0.66	.62	.62
Average											
Philadelphia		22974	53	39	9	0.43	0.54	0.76	0.68	.67	.67
Average											

extreme levels of segregation at the neighborhood level: East Germantown is 92% black, Fox Chase is 94% white. Neighborhoods with an overwhelming majority of one

racial group can have inaccurate indexes of internal segregation because a small cluster of minority residents can dramatically affect the evenness indices for the entire neighborhood. In addition, because whites are less concerned about living next to a black neighbor if there are only a few black residents in the neighborhood, these neighborhoods may have high evenness because the minority population did not reach a “critical mass” (South and Crowder 2005; Bruch and Mare 2006). Nonetheless, even when we include neighborhoods such as Germantown and Fox Chase, West Mount Airy has lower than average scores on both indices of evenness, indicating that its national reputation for being “integrated” is justified according to aspatial measures when compared to other integrated neighborhoods in Philadelphia.

When we turn to exposure/isolation (columns 11 and 12), the second most popularly studied dimension of segregation in scientific research on segregation, the results are much bleaker with regards to the fate of integration in Philadelphia. The isolation index measures the percentage in the average black residents’ block that is also black. That is, it measures whether or not black residents of each neighborhood live on primarily black blocks (column 11) or whether or not black and Hispanic residents live on blocks that are primarily populated with only black and Hispanic residents (column 12). Interpreting the index of isolation includes a step not necessary in interpreting indices of evenness: comparing the isolation index to the expected level of isolation. A

fully integrated neighborhood that is 50% black and 50% white will score 0.00 on the indices of evenness used above (dissimilarity and entropy). However, its isolation will be 0.50 as the typical black resident will live on a block identical to the larger neighborhood: one in which 50% of the population will be black as well. In addition, similar to the indices of evenness, non-integrated neighborhoods can have inaccurate values on the index of isolation because there are so few non-white residents that they will, because of that small population, almost have to live on integrated blocks. For example, Bridesburg, a neighborhood in Northeast Philadelphia, has only five black residents in 1990 and an isolation index of 0.10. Mayfair, with a population of over 30,000 in 1990 had only 84 black residents and an index of isolation of 0.04. As such, the average for non-integrated neighborhoods and for all Philadelphia neighborhoods may be biased by these neighborhoods that are over 90% white.

In terms of isolation, West Mount Airy and University City are again two of the more internally integrated neighborhoods of the 17 “integrated” neighborhoods in 1990. However, in this case, the differences are smaller than for the indices of evenness (West Mount Airy's isolation is 0.74 compared to an average of 0.83) and indicate a significant amount of isolation. The average black resident in West Mount Airy lives on a block on which roughly 75% of the residents are also black, even though only 60% of West Mount Airy's total population is black in 1990. In University City, the isolation index is lower (0.59), but that level of isolation is more than twice the level we should expect in a fully integrated neighborhood with the same percentage black (0.27). Nonetheless, compared

to other integrated neighborhoods, both University City and West Mount Airy have two of the better isolation results.

2000: (Re)segregation underway

Philadelphia as a whole lost just under 70,000 residents between 1990 and 2000. That statistic covers up an even greater white population loss in the city: 200,000 white residents left Philadelphia while the black population grew by roughly 40,000—in the process surpassing the white population as the largest single racial group in the city. At the same time, immigration to Philadelphia grew substantially as the Latino population grew by 50% to 120,000 and the Asian population nearly doubled from 42,000 to 72,000. While these statistics show that Philadelphia as a whole was undergoing important population shifts, it remains to be seen whether or not those changes reached integrated neighborhoods or were limited to moves into and out of previous racial enclaves.

Table 3.2 shows that the demographic changes in Philadelphia reached the integrated neighborhoods. By 2000, six of the 17 neighborhoods that were integrated in 2000 were no longer more than one standard deviation above the Philadelphia average for either the multigroup or the black/white measures of integration used to identify the neighborhoods in 1990. Except for Chestnut Hill, all of the neighborhoods that moved from integrated to non-integrated became predominantly non-white, consistent with the traditional invasion/succession theory of residential turnover (Schwirian 1983; Park 1952). It may be that the cross-sectional analysis in 1990 used to identify integrated neighborhoods mostly identified neighborhoods in the midst of a transition from being

Table 3.2 Measures of Internal Integration for “Integrated” Neighborhoods in 2000

Neighborhood	Criteria Met	1990 Population	% White	% Black	%Asian /Latino	Entropy Index	Black/white Entropy Index	Black/ white D	Black and Hispanic/ white D	Black/white isolation	Black and Hispanic isolation from white
Cedar Park	None	15602	22	70	8	0.21	0.22	0.47	0.46	.98	.96
Chestnut Hill	None	9482	78	16	5	0.34	0.42	0.68	0.65	.53	.47
East Mount Airy	None	16457	14	83	6	0.29	0.34	0.56	0.56	.84	.76
East Oak Lane	None	16669	16	71	13	0.33	0.37	0.65	0.64	.75	.71
Eastwick	Both	14383	36	59	5	0.21	0.18	0.42	0.41	.44	.4
Elmwood	Both	27370	30	56	13	0.25	0.21	0.41	0.41	.73	.65
Fairhill	None	27828	4	24	8	0.33	0.45	0.7	0.46	.91	.56
Fairmount	Both	21416	62	24	12	0.34	0.44	0.62	0.6	.64	.55
Fishtown	All Groups	14601	63	17	19	0.41	0.52	0.72	0.67	.62	.45
Gray's Ferry	black/white	12369	38	57	5	0.55	0.6	0.76	0.75	.86	.83
Kensington	None	21708	4	37	59	0.18	0.28	0.54	0.45	.26	.15
Olney	All Groups	37279	15	45	40	0.12	0.11	0.31	0.3	.78	.50
Overbrook	black/white	30540	26	69	4	0.26	0.28	0.47	0.47	.8	.77
University City	black/white	22535	49	21	28	0.22	0.29	0.51	0.43	.54	.44
West Kensington	black/white	11287	9	19	70	0.28	0.55	0.71	0.6	.87	.36
West Mount Airy	black/white	13216	44	51	4	0.21	0.22	0.43	0.42	.66	.63
Wynnefield	black/white	27267	27	66	6	0.38	0.45	0.67	0.66	.85	.82
Integrated Neighborhood Average		19458	35	46	19	0.3	0.35	0.57	0.53	.73	.61
Non Integrated Average		22774	48	41	11	0.3	0.35	0.63	0.56	.62	.55
Philadelphia Average		21991	44	43	12	0.3	0.35	0.61	0.55	.65	.56

predominantly white to predominantly non-white. This highlights the need for further study of the trajectory of individual neighborhoods over extended periods to more accurately identify integration as either a stable characteristic of a neighborhood or a moment during the transition of a neighborhood from predominantly white to majority-minority (Bader 2010).

Turning to those six neighborhoods that stayed integrated compared to the rest of Philadelphia's neighborhoods, we see significant shifts towards segregation that provide strong suggestions that they are also transitioning towards segregation, albeit at a slower pace. Some of the neighborhoods that meet the four group entropy score criteria do so only because they have roughly even numbers of black, Hispanic and/or Asian residents with a small white population. Olney, for example, became a large ethnic enclave for Asian immigrants, primarily Koreans, and only 15% of its population was white in 2000, compared to 43% in 1990. West Kensington has a high entropy score for its black/white value, but only because the majority of its white and black residents were replaced by Hispanic residents who are now 70% of its population. Wynnefield, while it still meets a criteria for inclusion as "integrated," saw over 1000 of its white residents leave between 1990 and 2000 while its black population nearly doubled from 9,700 to 18,000. Eastwick saw a similar demographic shift to Wynnefield, as it went from roughly 60% white to roughly 60% black; while Eastwick continues to be "integrated," it moved from majority-white and integrated to majority-black and integrated. Elmwood, Grays Ferry, and Overbrook went through the same shift, as their white populations all dropped by more than 10% of their 1990 share by 2000.

Four neighborhoods that remained integrated do not fit the traditional narrative of racial transition described above: Fishtown, Fairmount, University City and West Mount Airy. Fishtown had a slight plurality of white residents in 1990. By 2000, Fishtown lost 5000 residents, most of whom were black residents as Fishtown's white population grew from 45% of its total population to 63%. Fairmount grew by roughly 1,000 residents, mostly consisting of white and Asian movement into the neighborhood while over 2,000 black residents left the area. University City's population grew even more—by almost one-third between 1990 and 2000: while the white population grew by 800 and the black population grew slightly, the bulk of that growth came from the more than tripling of University City's Asian population from 1,600 to over 5,000 residents. West Mount Airy, on the other hand, lost nearly one quarter of its population, losing 1,000 white residents and over 3,000 black residents in the 1990s and seeing little to no change in its Hispanic and Asian populations. Overall, this made West Mount Airy appear more integrated as a whole: it went from 60% black to 51% black and from 38% white to 44% white.

Having established the wide variety of overall demographic changes the integrated neighborhoods experienced, I now look at the internal dynamics of those shifts. Unlike the overall statistics that indicate that most of these neighborhoods are trending towards becoming more segregated, the internal dynamics paint a different picture. All eleven neighborhoods that stayed more integrated as a whole compared to the average Philadelphia neighborhoods saw their indices of evenness and isolation fall with the exception of Wynnefield, which saw its evenness fall while its isolation grew slightly, from 0.81 to 0.85. On the other hand, these findings are mirrored by the results from all

Philadelphia neighborhoods as the average neighborhood's evenness and isolation scores also fell between 1990 and 2000. It appears from the indices that the integrated neighborhoods of Philadelphia are undergoing two distinct patterns. As single entities, they are growing less integrated as many of the neighborhoods are no longer integrated compared to the rest of the city and/or are trending towards that result. Internally, however, the neighborhoods' blocks are growing more and more similar to each other as both the neighborhoods' indices of evenness and exposure are generally dropping. This may be due, in part, to the change in the baseline comparison—a block that is 90% black will contribute less to the dissimilarity index of a neighborhood or city that is 60% black compared to one that is 50% black. Expanding our study to include 2010 may help illuminate which of the two trends is stronger.

Changes between 2000 and 2010: Resegregation nears completion

When the 2010 Census results were first released, local Philadelphia media largely focused on heralding the increase in immigration to the city and its population increase after three straight decades of population loss. Philadelphia appeared to be a resurgent city, particularly exciting for residents because census estimates had predicted that Philadelphia would continue to lose population between 2000 and 2010. Less often reported was the sorry state of racial segregation in Philadelphia. Column 2 in Table 3.3 makes clear that any movement towards integration between 1990 and 2000 was illusory: by 2010, only four (Cedar Park, Olney, University City, and West Mount Airy) of the original seventeen neighborhoods are still integrated by either of the two criteria. Like in

2000, Olney's population is predominantly black and Asian, and its white population in 2010 had dropped to only 6% of the entire neighborhood. Another of those four neighborhoods, Cedar Park, had slipped into segregation in 2000 and barely returned to integration in 2010 due to the influx of 4000 new white residents between 2000 and 2010. Cedar Park is located directly west of University City and, more likely than not, the influx of white residents is the beginning of its integration into a larger, university centered neighborhood created mainly via the influence of the University of Pennsylvania in the area. For example, the catchment area of the Penn Alexander school, a state of the art public school built and partially funded directly by the University of Pennsylvania at the turn of the century, includes a section of Cedar Park as well as parts of University City. Further, the University City District is a 501(c)3 created in 1997 to foster revitalization and commercial restoration that includes all of the Cedar Park neighborhood as part of its special services district. Its board includes multiple employees of the University of Pennsylvania, including its current chairperson and many of its staff members, including its executive director, are Penn alumni. University City and West Mount Airy are the only two remaining neighborhoods that stayed integrated from 1990 through 2010. However, University City's population saw even more significant gentrification as the black community lost another 2000 residents, replaced mainly with a continued increase of Asian residents. West Mount Airy also continued to shrink in population between 2000 and 2010, losing over 3000 residents, in this case almost evenly split across its white and black populations. Since 1990, West Mount Airy lost almost

Table 3.3 Measures of Internal Integration for “Integrated” Neighborhoods in 2010

Neighborhood	Criteria Met	1990 Population	% White	% Black	%Asian /Latino	Entropy Index	Black/white Entropy Index	Black/ white D	Black and Hispanic/ white D	Black/white isolation	Black and Hispanic isolation from white
Cedar Park	black/white	19960	37	52	11	.21	.28	.53	.52	.98	.98
Chestnut Hill	None	9892	76	17	6	.25	.24	.60	.60	.99	.99
East Mount Airy	None	16634	19	76	4	.28	.18	.43	.42	.92	.92
East Oak Lane	None	17706	8	80	12	.19	.14	.37	.37	.87	.87
Eastwick	None	15218	14	78	8	.13	.11	.32	.32	.91	.92
Elmwood	None	28015	8	79	13	.16	.38	.63	.43	.91	.97
Fairhill	None	27903	3	21	76	.31	.40	.62	.56	.56	.54
Fairmount	None	21893	69	18	12	.26	.23	.64	.56	.56	.57
Fishtown	None	16711	70	12	8	.31	.24	.53	.41	.23	.28
Gray's Ferry	None	13763	22	65	13	.26	.22	.63	.63	.99	.99
Kensington	None	16166	70	6	24	.31	.37	.64	.64	.98	.98
Olney	All Groups	35749	6	53	41	.10	.32	.51	.51	.91	.91
Overbrook	None	29901	13	83	4	.25	.14	.35	.30	.56	.64
University City	All Groups	21986	52	12	35	.08	.43	.61	.57	.75	.91
West Kensington	None	8515	12	14	74	.23	.21	.42	.41	.57	.58
West Mount Airy	black/white	9234	54	41	5	.19	.21	.51	.51	.99	.99
Wynmfield	None	23199	22	70	7	.29	.36	.59	.58	.85	.85
Integrated Neighborhood Average		19555	32	45	21	.23	.26	.53	.49	.80	.82
Non Integrated Average		23403	41	41	16	.23	.33	.58	.51	.60	.63
Philadelphia Average		22441	39	42	17	.23	.31	.56	.51	.65	.67

half of its population, shrinking from 17,434 residents to only 9,892 in 2010. 70% of that population loss occurred within the black population which fell from over 10,000 residents in 1990 to roughly 3,500 in 2010. While West Mount Airy's total population continues to be roughly equally white and black, that is now true for half as many residents as before.

Unlike between 1990 and 2000, the indices of internal integration between 2000 and 2010 show that even for University City and West Mount Airy, integration does not persist at the block. While West Mount Airy's entropy indices are virtually identical (0.19 and 0.21 compared to 0.21 and 0.22 in 2000), its dissimilarity score rose from 0.43 to 0.51. More damning, the black isolation score jumped from 0.66 to 0.99, indicating that the average black resident lives on a block that is almost entirely black. University City underwent similar internal changes, as its dissimilarity grew the same amount as West Mount Airy's and its index of black-white isolation grew from 0.54 to 0.75, while its index of black and Hispanic isolation from whites grew from 0.44 to 0.91. In short, the total numbers indicate that both neighborhoods' populations continue to include a mix of both black and white (and in University City, also Asian) residents, but the indices of segregation indicate that between 2000 and 2010, even these two unique neighborhoods slid towards segregation, regardless of the influence of a large, wealthy research institution (University City) or the power of a history as a purposefully and stably integrated neighborhood (West Mount Airy).

To summarize, integration in Philadelphia is, as research predicts, only a stage in the process of racial turnover for fifteen of the seventeen neighborhoods that were integrated in 1990. For the remaining two neighborhoods—both of which have unique aspects that could support stable integration—internal indices indicate that while integration appears to persist, that may be true only on at a larger geographic scale. When one compares the integration of individual blocks in these neighborhoods, they began to trend towards segregation after 2000. In the next two sections, I explore each neighborhood using the GIS methodology described above to determine whether or not mapping supports the findings from traditional aspatial measures of segregation or finds a different trend in both University City and then West Mount Airy.

Mapping Gentrification: University City from 1990 to 2010

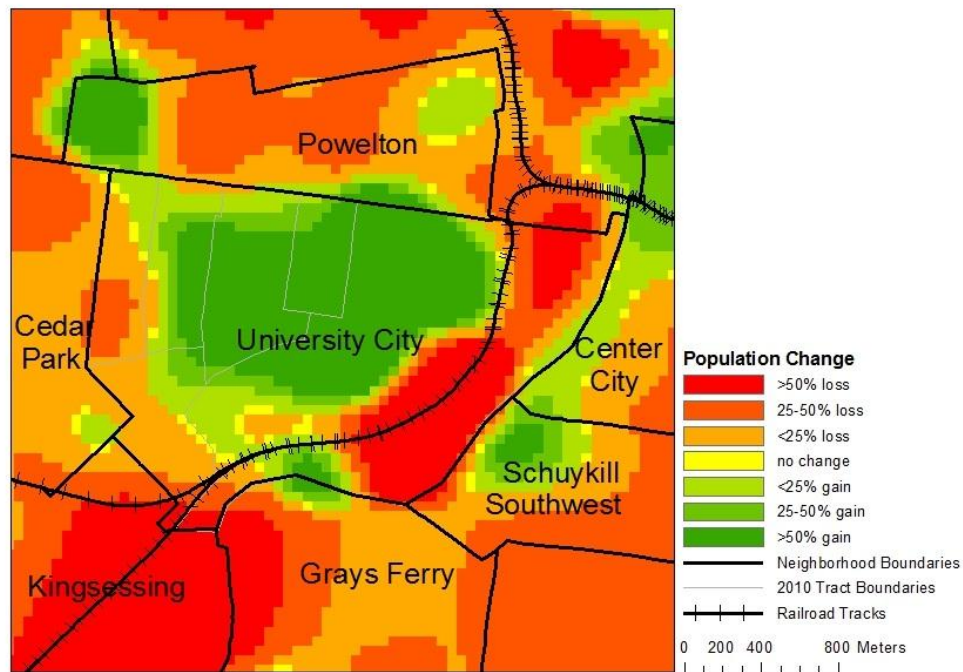
University City is located due west of Philadelphia's center city business district across the Schuylkill River. It is bounded on the north by Market Street, the main east-west corridor in Philadelphia, and on the west primarily by 45th street, encompassing roughly 2.3 square miles. Nearly half of that area is taken by the campus of the University of Pennsylvania, mainly between 33rd street and 40th street. University City's housing stock mostly consists of rental units (over 90% in 2000), often in remodeled Victorian detached houses. Just over 34% of the houses are rowhomes. Home values are higher than the Philadelphia average: in 2006, the median sale price was over \$300,000 in University City compared to under \$100,000 across all of Philadelphia. University City

has a nearly 30% poverty rate, though much of that high poverty may be due to the large presence of undergraduate and graduate students in the area. According to Penn's Office of Off-Campus Services, in 2010 over 5,000 students lived off campus in University City.

Unlike Philadelphia as a whole, University City's population grew by almost 30% in the 1990s before decreasing slightly between 2000 and 2010. Much of that growth can be attributed to the efforts of the University of Pennsylvania to locate more of its faculty and graduate student housing in the neighborhood. While the overall population grew its racial makeup changed dramatically, from roughly 60% white and 40% black to mostly white and Asian with only 12% black in 2010. I begin the spatial examination of University City's population by mapping where the population underwent change between 1990 and 2010 in Figure 3.3.

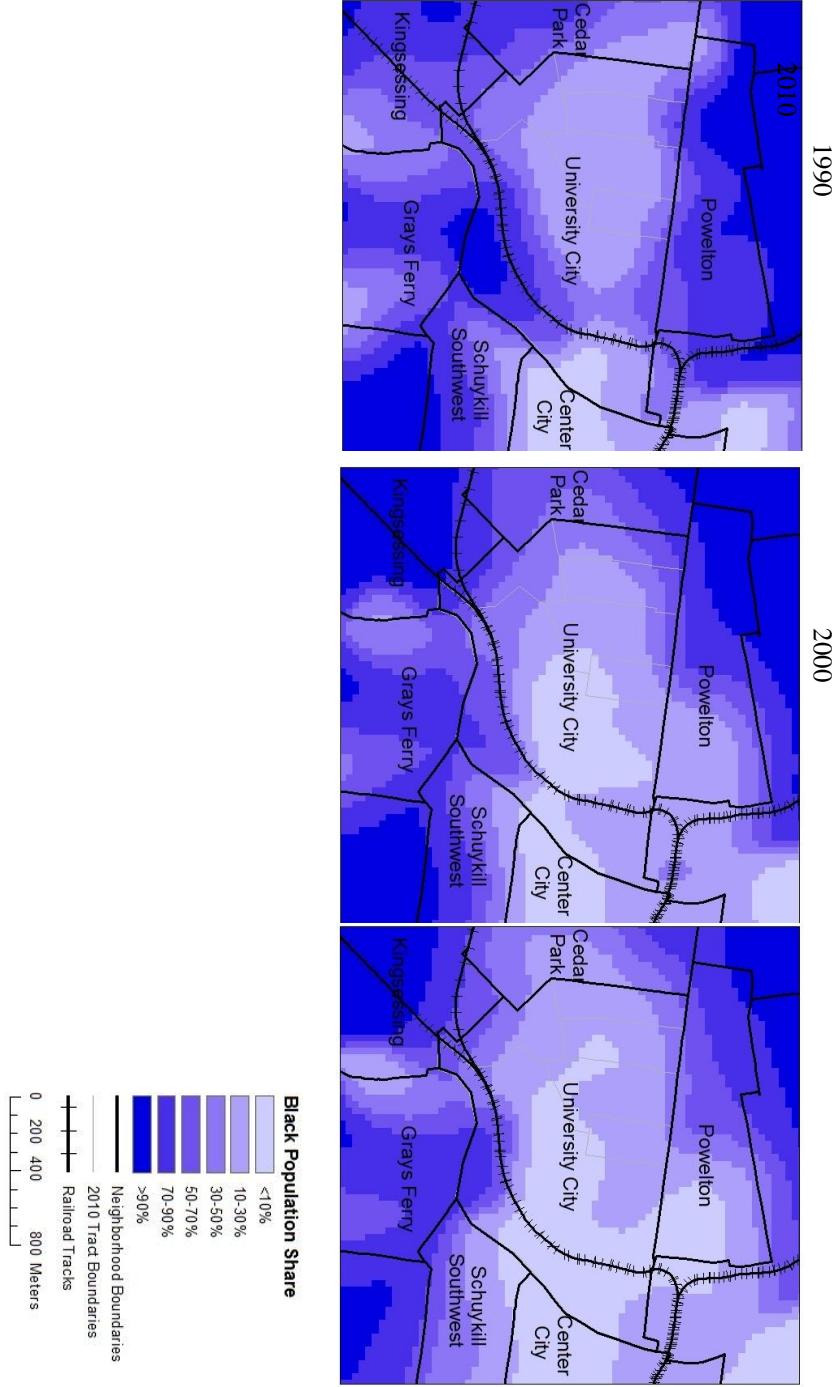
Most of University City saw substantial population growth—with the exception of the eastern part of the neighborhood on or near the Schuylkill River where the University of Pennsylvania's hospital and athletic fields expanded between 1990 and 2010. More important is University City's unique situation compared to the surrounding areas: Every other neighborhood adjacent to University City underwent significant population loss at the same time that University City itself was growing dramatically. The population loss in Kingsessing and Cedar Park, in fact, spills over into University City. While Cedar Park's population grew slightly overall between 1990 and 2010, much of that growth was located on the western part of the neighborhood away from University City's growth. The areas near University City saw small population loss. Overall, the map shows that

Figure 3.3. Change in Total Population in University City and Surrounding Areas
between 1990 and 2010



University City is clearly undergoing a unique population growth that does not extend beyond its own borders into the larger West Philadelphia region. Figure 3.4 maps the black population in University City, with additional gray lines indicating the boundaries of census tracts within University City. As a total, the black population share of University City shrank from 27% to 12% between 1990 and 2010. However, it is unknown whether or not that change in population size was related to an increase or decrease in segregation levels within the neighborhood. Importantly, because Hispanic and Asian residents became a large portion of the population of University City, areas with low numbers of black residents are not necessarily being replaced with white

Figure 3.4. Black Population in University City and Surrounding Area 1990-2010



residents. Thus, while discussing the figures, it is important to remember that when black residents leave, these maps do not show who is replacing them. The first panel of Figure 3.4 shows the black population in 1990. In 1990, most of University City had between 10 and 30% black population. The southeast corner of the neighborhood was the only part of the neighborhood that was majority black, including a large section that was over 70% black. Remember from Figure 3.3 that the southeast corner was also the area that underwent the most population loss between 1990 and 2010 as well.

The middle panel of Figure 3.4 shows the black population share in 2000. By 2000, the black population share of University City had fallen from 27% to 21%. Already, the southeast corner of University City is no longer predominantly black. A smaller part of the corner remains majority black, but almost none is over 70% in 2000. In addition, there is a clear spatial pattern to the loss of black population in the neighborhood: the central part of the neighborhood including the University of Pennsylvania's main campus area and just north of the campus now have less than 10% black populations and the black population grows larger the further from the university campus one travels.

The panel on the right shows the black share of the population in 2010. By 2010, University City was only 12% black. Even with such a small black population, the map shows that there is significant clustering of the black population. The area with less than 10% black population expanded between 2000 and 2010 both north into neighboring Powelton, well past the boundaries of the University of Pennsylvania's campus. In

addition, the exodus of black residents from University City spread west between 2000 and 2010 and that exodus appears to have affected Cedar Park. As hypothesized earlier, this final panel provides some evidence that Cedar Park's apparent reintegration in 2010 is possibly due to the spread of the white population past University City's original neighborhood boundaries and into its surrounding areas. The tables discussed earlier show that the black population shrank in University City between 1990 and 2010. By incorporating mapping, we can see not only how that population shrank, but the spatial pattern of that loss: a nearly linear process in which the black population was pushed first out of the areas closest to the University of Pennsylvania and then pushed further west and north, even affecting surrounding neighborhoods.

Mapping University City also demonstrates the inaccuracy of census tracts. The black residents of University City show a clear pattern of residency: they largely lived on the borders of the neighborhood and got pushed further and further out. Unfortunately, the census tracts were not aligned to those changes: the census tract in the southwest corner of University City, tract 77 in Philadelphia, saw its black population shrink from 48% in 2000 to roughly 30% in 2010. The map shows specifically that the black residents in the northern section of that census tract left while the black population in the southern part of the tract stayed stable. In short, the racial residential changes in University City did not correspond to census geographies. Next, I explore whether or not the mapping leads to the same disappointing findings in Philadelphia's "stably integrated" neighborhood of West Mount Airy.

Mapping as Early Warning: Spatial Racial Clustering in a “Stably Integrated” Neighborhood

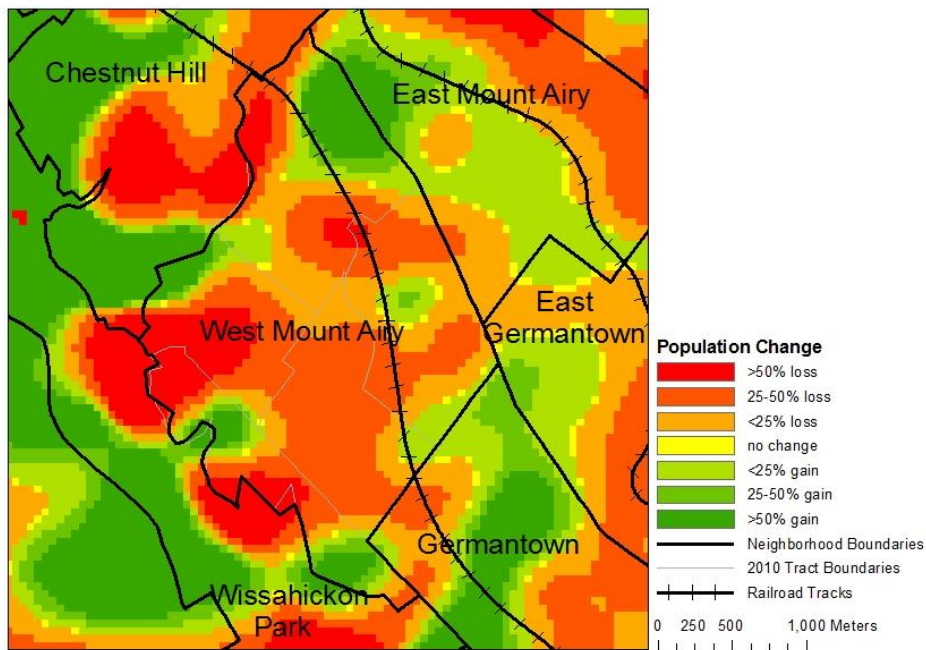
Located in Northwest Philadelphia, West Mount Airy is bordered to the west by Wissahickon Park and to the north by Chestnut Hill, historically one of Philadelphia's wealthiest neighborhoods. To the east, West Mount Airy and East Mount Airy (a predominantly black neighborhood) are divided by Germantown Avenue, a two lane street that is the main commercial hub in that section of Philadelphia. South of West Mount Airy is Germantown, another predominantly black neighborhood with over 20% of its population below the poverty level in all three censuses. West Mount Airy was 60% black in 1990 and 52% black in 2000 before becoming majority white in 2010 (54% white). Few Asians and Hispanics live in the area—in 2000 only 4% of the population identified with either group, and that only grew to 5% in 2010. Unlike most of Philadelphia, West Mount Airy's housing stock is primarily detached, single family houses instead of rowhomes (only 22% of residences in West Mount Airy are rowhomes compared to a city average of over 62%). The vacancy rate was less than 2% (one fifth of the city average) and the poverty rate is consistently below 10%. In short, West Mount Airy is a relatively affluent neighborhood bordered on one side by a wealthy neighborhood and by a less prosperous black neighborhood on the other.

Before exploring the spatial clustering of West Mount Airy residents, it is valuable to consider the spatial aspect of West Mount Airy's loss of nearly half its residential population between 1990 and 2010. Figure 3.5 is a map of these population

changes. Similar to University City, the majority of the neighborhood experienced the same population transition over the twenty years under study. Most of West Mount Airy lost population. However, while most of West Mount Airy lost population, a few areas saw their populations grow, mainly a large area on the border between East Mount Airy and West Mount Airy, but also a small area close to Germantown. Areas near Wissahickon park also saw their populations grow, but those areas have very small population densities, so that may be affected by very small actual changes to the population. In general, the southern and western portions of West Mount Airy appear to have lost the most population, while the northern section of the neighborhood includes areas that both lost and gained population.

While West Mount Airy lost nearly half of its population, it continued to have a nearly even split of black and white residents in all three censuses. That split shifted, however, from majority black to majority white between 1990 and 2010 and the neighborhood's index of isolation moved from high (.74 in 1990 and .66 in 2000) to an extreme level of black-white isolation in 2010 (.99). It remains to be seen whether or not that increase in isolation is related to an increase in spatial clustering. Figure 3.6 shows the black population share in 1990, 2000, and 2010. Because Hispanic and Asian residents never make up more than 5% of the total population, areas in which the black population share is low will therefore have a high white population share, unlike University City. In other words, if an area has a very small proportion of black residents, we know that it has a high proportion of white residents in West Mount Airy. In

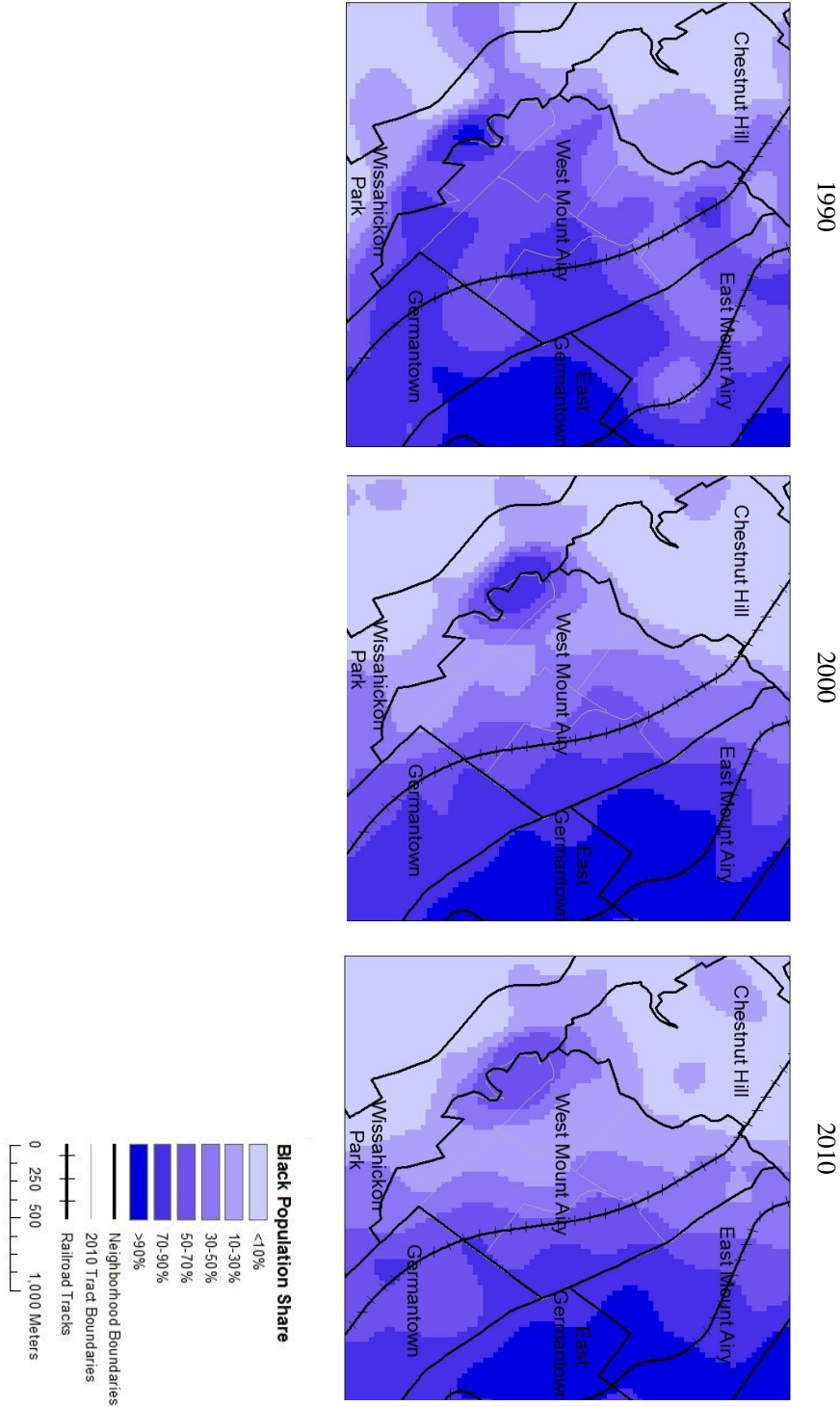
Figure 3.5. Population Change in West Mt Airy and Surrounding Areas 1990-2010



addition, I include a representation of the Southeastern Pennsylvania Transportation Authority's (SEPTA) regional railroad lines that runs through West Mount Airy. I include the railroad tracks for three reasons. First, previous research has shown that railroad lines often are strongly associated with segregation levels and locations (Ananat 2011). Second, the railroad is a good proxy of housing type in West Mount Airy: the rowhomes are predominantly found east of the railroad track while the larger, detached houses are overwhelmingly found to the west of the railroad in the neighborhood. Finally, the railroad provides an alternative to census tracts for discussing potential intra-neighborhood divisions, one that the figures show to be a beneficial alternative when discussing West Mount Airy's internal segregation.

The first panel in figure 3.6 shows the black population share in West Mount Airy and surrounding areas in 1990. West Mount Airy itself in 1990 was 60% black and there appears to be little clustering in the map. Some areas to the south and east of the neighborhood are between 70 and 90% black, but that result partially is due to spillover from Germantown and East Germantown, two overwhelmingly black neighborhoods in 1990 (79% and 92% black in 1990). Similarly, Chestnut Hill was majority white in 1990, and it is no surprise that the only areas in West Mount Airy that are majority white in 1990 are adjacent to Chestnut Hill in the north. Overall, however, West Mount Airy's population seems to show little clustering in 1990—the majority of the neighborhood has a slight black majority, just as the aspatial indices would lead one to expect. The second panel shifts forward ten years to 2000, when West Mount Airy had almost equal black and white populations. However, it also had lost roughly 4000 residents (roughly 20% of its total population) during that decade. The aspatial indices explored earlier indicate that West Mount Airy appears to be more integrated: its measures of evenness and isolation all fell. The map, however, tells a dramatically different story. Unlike 1990 where the black population seemed roughly evenly dispersed throughout the entire neighborhood, the neighborhood's residents are significantly more racially clustered in 2000. The western half of the neighborhood is now majority white, including significant areas where blacks make up less than 30% of the population, even as they are still over 50% of the total population in the neighborhood. To the east, the black population is now largely clustered in areas near East Mount Airy and East Germantown, two predominantly black neighborhoods with significantly higher poverty rates than West Mount Airy. Remember

Figure 3.6. Black Population in West Mount Airy and Surrounding Area 1990-2010



as well that the housing stock to the east is mainly rowhomes, while the western half of the neighborhood is mostly detached homes. A small cluster of black residents also appears next to Wissahickon Park in the west. That housing is smaller than the other detached homes to the east and is largely isolated from those other houses by a large wooded area known as Carpenter's Woods. Spatially and visually, West Mount Airy became significantly more segregated between 1990 and 2000, a transition that is missed by traditional indices of segregation.

The traditional indices of segregation begin to show that segregation between 2000 and 2010, as the index of dissimilarity returns to 1990 levels and the index of isolation grows dramatically. However, the entropy index stayed low, indicating that while West Mount Airy both grew whiter (now, for the first time, majority white), it also grew more somewhat more segregated. The map in panel three of Figure 3.6 shows the continued unfortunate impact that population changes have on racial clustering. While there are still few areas with almost entirely white populations (>90%), a much larger percentage of the neighborhood is now overwhelmingly white (>70% white). Note, that the traditional measures of evenness presented in Tables 3.1 through 3.3 did not capture this substantial increase in the degree of internal segregation in West Mount Airy until 2010. Visually, on the other hand, the change is clear: West Mount Airy is highly bifurcated by 2000 with a largely black population in the southeast and a predominantly white cluster along the western and norther edges of the neighborhood, a bifurcation that only increases in 2010.

Perhaps even more disheartening is that the pattern for West Mount Airy, an area known as uniquely invested in and staying integrated appears to be the natural extension of nearby neighborhoods. In other words, both census tract and NIS neighborhood boundaries that were relatively accurate representations of neighborhood boundaries in 1990 are less accurate in 2000 and practically irrelevant in 2010. The map of West Mount Airy in 2000 depicts a border area between two populations, one white to the northwest and one black to the east, rather than a single integrated neighborhood in its own right. That change in racial clustering did not occur in isolation to the neighborhoods that surround West Mount Airy. As others have shown, extra-local changes help model the likelihood of white flight from a census tract or neighborhood (Crowder and South 2005) and can also predict other outcomes within specific neighborhoods (Morenoff, Sampson, and Raudenbusch 2001). The change between 1990 and 2010 in West Mount Airy indicates that parts of the white population of West Mount Airy are moving to other wealthy and white neighborhoods while the black population that remains in West Mount Airy is staying closer to two poorer and predominantly black neighborhoods, a reality that has been identified before in qualitative studies of the black middle class (Pattillo-McCoy 1999). In addition and foreshadowing findings in the next chapter, the border between black and white residents appears to follow the railroad tract that runs through West Mount Airy. The entire subsection of West Mount Airy that is majority black is confined to the east side of the railroad track, while, until the tracks get close to Chestnut Hill (in 2010 over 75% white) the white population is almost entirely confined to the west side of the tracks.

Conclusion: The Need for Micro-Level Examinations of Segregation

In this chapter, I studied the internal dynamics of racial segregation at the neighborhood level. Unlike most studies of racial segregation that rely either on city-wide indices of segregation or micro-level individual residential decisions, I studied the meso-level of the neighborhood. To do so, I first explored whether or not integration persists over time at the neighborhood level. Social scientists have long shown that integration is an unstable proposition, both theoretically (Schelling 1971, 1972) and empirically (Bobo and Zubrinsky 1996; Charles 2007; Bruch and Mare 2006; Friedman 2008). My study of Philadelphia's neighborhoods confirmed this line of research, as only two of seventeen neighborhoods were integrated in 1990, 2000, and 2010 using traditional measures of residential racial segregation.

Having shown that racial integration is unstable in the majority of Philadelphia's neighborhoods, I then turned to two case studies of neighborhoods that were integrated according to traditional measures of evenness in all three censuses: University City and West Mount Airy and incorporated GIS methods to explore the spatial aspects of residential integration in those neighborhoods. University City's integration was the displacement of black residents out of the neighborhood and their replacement by both Asian and white immigrants. West Mount Airy appeared, according to the aspatial indices, to be a better case of stable integration—in fact, it is a nationally recognized neighborhood proud of its black/white residential integration since the 1960s. Traditional

indices of evenness and exposure depict a neighborhood in which the white and black populations grew slightly more segregated between 1990 and 2000. The indices described conflicting results in 2010: measures of black/white evenness showed small improvements in residential segregation, but the isolation index found a black community that was almost entirely isolated from white residents. Using these traditional measures indicated that between 2000 and 2010, West Mount Airy began to slide towards greater racial segregation as its population fell.

Importantly, the spatial analysis of West Mount Airy identified that its slide towards racial segregation a decade earlier than the aspatial analysis. By 2000, West Mount Airy had begun to show a clear spatial pattern of racial segregation. If this result is true outside of case studies, that has powerful implications for the accuracy of previous analyses of segregation in the United States; analyses that rely on aspatial measures may be significantly underestimating the extent of racial segregation.

Another valuable finding from this chapter is the importance of not relying on census tracts as proxies for neighborhoods. Neither the census tracts contained in University City nor those of West Mount Airy conform to the racial segregation shown on the map. Relying on census tracts as proxies for neighborhoods provides a form of measurement error that can lead to underestimations of the extent (and potentially, the impact) of racial segregation. The maps provide the additional benefit of incorporating important physical aspects of the geography as they made clear the importance of railroad tracks in shaping the racial segregation in West Mount Airy. The railroad tracks were

associated with the boundary between the black and white parts of West Mount Airy. “Being on the wrong side of the tracks” became, between 1990 and 2000, a reality that previously had not existed in that neighborhood.

Spatial clustering is an important component of a complete accounting of racial residential segregation in urban areas (Massey and Denton 1988; Reardon and Sullivan 2004). However, because measuring multiple dimensions of segregation complicates both analysis and interpretation, many sociologists have used only measured evenness to analyze racial segregation levels (Iceland 2004; Fischer, Stockmayer, Stiles, Hout 2004; Lee et al. 2008; Parisi et al. 2011). As this chapter demonstrates, through the case study of West Mount Airy and the comparison of seemingly integrated neighborhoods in 1990 and 2000, by ignoring racial clustering sociologists offer a conceptually inaccurate (and possibly overly positive) view of racial residential segregation in urban areas (see also Hayslett and Kane 2011).

This chapter also escapes methodological issues long associated with attempting to capture spatial realities via aspatial indexes. Massey and Denton (1988) argued that early measures of clustering were inadequate measures of the phenomenon. More recently, geographers and demographers have argued that clustering can be captured by spatially adjusting traditional measures of evenness. However, as this chapter illustrates, clustering is a conceptually distinct and relevant aspect of segregation (clustered and unclustered). Mapping is a simple, if relatively novel, method for exploring and identifying racial clustering within a neighborhood. While maps may not provide the

interpretative simplicity of a score or index, they do provide a more accurate and potentially more accessible means for demonstrating the persistence of American racial residential segregation for both academics and laypeople. Maps also can show the spread of racial clustering across neighboring communities or any association between changes in one neighborhood and its surrounding communities. Moreover, such maps can identify locations for fruitful qualitative and policy work: the maps show specific areas where racial turnover was most dramatic and/or widespread. Not only are such areas valuable locations to study for insight on the individual decisions that cumulatively create segregation, but it identifies areas in which policy initiatives to support integration may provide the most benefit and/or be most needed. In addition, these locations may be valuable sites for future ethnographic work on the actual processes that occur in areas with dramatic turnover that are otherwise spatially very distinct from each other (West Mount Airy lacks an institution like the University of Pennsylvania yet experienced the same move towards clustering between 1990 and 2000, a similarity traditional measures of segregation did not capture).

This chapter also illustrates two advantages to using socially-relevant neighborhood definitions when studying racial residential segregation. First, it provides scholars an additional scale with which study segregation. As Fischer and colleagues (2004) found, segregation is a multi-level phenomenon (Parisi et al. 2011). By comparing national rates of segregation to show that black segregation levels have changed mostly at the neighborhood level and foreign born segregation is primarily at the metropolitan level, they highlight the importance of considering segregation at a more granular level

than citywide indices provide. I extend that illustration by exploring the internal segregation of specific neighborhoods in a way that problematizes our understanding of what “stably integrated” (Ferman, Singleton, and DeMarco 1999) neighborhoods look like on the street. In short, evidence from Philadelphia neighborhoods suggests that assertions of stable integration are supported by aspatial measures of evenness. Unfortunately, when one also considers the clustering of individuals within a neighborhood, even in West Mount Airy—a neighborhood nationally recognized as stably integrated—integration is less stable than it seemed.

While my findings show that residents of integrated neighborhoods move towards racial clustering, that does not mean that non-white residents in integrate neighborhoods do not benefit from the privileges and structural support that whites in these neighborhoods receive (Krivo and Peterson 2010). Nonetheless, my findings offer another warning signal that integration is an unstable position and one that requires constant vigilance to ensure that extra-local and local influences do not lead to a form of benign neglect and future re-segregation (Parisi, Lichter, and Taquino 2011; Van de Rijt, Siegel and Macy 2009). In addition, it expands Fischer and colleague's (2004) argument that sociologists would benefit by exploring racial residential segregation on multiple geographic scales and identifying a methodology for examining the micro-process of segregation in a meaningful and substantively rigorous manner. Finally, it joins a growing literature that explores how the introduction of mapping and spatial analysis can enhance the analysis and presentation of sociological studies of urban residential segregation (Grengs 2007; Wong 2005).

Building on these findings, I next explore extra-local effects like those I found in the case study of West Mount Airy. Neighborhoods do not exist in a vacuum and surrounding areas can have effects on internal structures. As such, now that sociologists have access to socially meaningful definitions of boundaries in place of administrative proxies such as census tracts, it is possible to identify where boundaries create a buffer between two distinct populations and where they do not. After discussing the literature on what a neighborhood boundary is and why it matters for individual outcomes, I use the levels of residential segregation seen in adjacent neighborhoods to create a typology of neighborhood boundaries as either porous, obstacles, or walls, depending on how similar the populations are on both sides of those boundaries.

Chapter 4:

Boundaries, Barriers, and Citywide Levels of Segregation

Methodological limitations force social scientists to assume that social space is either fully discontinuous or continuous across the physical geography of the city in efforts to measure racial residential segregation. Indexes that aggregate values based on subunits of the city (traditionally the census tract) assume that the racial segregation of the city is entirely discontinuous: the population of each individual census tract is unaffected by the local environment in which it is located. While Wong (2005; 1993) has taken steps to improve upon that inaccurate assumption, he still relies on the census tract's boundaries (or other subunit) as an important barrier—he smartly extends the “neighborhood” to the census tracts directly surrounding the tract of interest to minimize that assumption of complete discontinuity. The continuous assumption, used in surface-density analyses of segregation, treats the physical geography as superfluous—the city is, in effect, flat. However, geographers have long shown that cities are far from flat; many spaces are, due to redlining, architecture, historical events, or malignant neglect, areas that can be stigmatized and racialized even if they are geographically proximate (see: Neeley and Samura, 2011; Lipsitz 2007). The fact that social space is not flat was at the heart of even the earliest Chicago school studies of the urban environment (Hunter 1982), yet surface density analyses of segregation start with that premise.

The previous chapter illustrated how spatial analysis can explore intraneighborhood residential patterns. Neighborhoods such as West Mount Airy (and, by extension, cities) may appear diverse according to aspatial indices, but spatial analytic methods showed that West Mount Airy's population was sliding into a segregated state a full census cycle before the aspatial indices gave the same results. In addition, the results showed that major roads and railroad tracks were associated with the encroaching residential segregation: being on the "wrong side of the tracks" was more than a euphemism, it was the reality. Railroad tracks helped shape the geography of residential segregation in West Mount Airy; and those findings show that residential segregation in Philadelphia is not continuous because barriers affect its patterning. Sociologists have yet to directly incorporate those barriers into measures of black/white residential segregation. This chapter does so for the first time.

In this chapter, I also compare the effect of those barriers on racial segregation for all four major racial and ethnic groups. I first look at black/white segregation as it encompasses the majority of Philadelphia's population in 1990, 2000, and 2010. It is also the segregation that is most implicated in negative outcomes and inequality (Charles 2003; Massey and Denton 1993). Moreover, blacks are historically hypersegregated from whites in Philadelphia and have been for decades (Massey and Denton 1989)¹. Since the 1990s Philadelphia has also seen an increase in Hispanic and Asian immigration. As new arrivals to the city, these racial and ethnic minorities may have access to different

¹ Hypersegregation occurs when a racial group reaches a threshold of .6 on at least four of the five components of segregation: evenness, exposure, concentration, clustering, and centralization.

neighborhoods and may use different cues to determine where to live compared to white and black residents (Logan and Zhang 2010; Iceland 2009).

The chapter concludes with an examination of impact of incorporating borders not on city-level indexes of segregation, but instead on the local patterns within the city that are aggregated in a city-level index. In the previous chapter, I do so by incorporating mapping as a main component of my analytic technique because it allows for unique insight into the local effects of borders that are missed by traditional sociological analytic techniques. I do the same here to show that while barriers generally have small impacts on citywide indices of evenness, they have substantial impacts on the local patterns within the city.

Data and Methods

One of the most important potential impacts of incorporating barriers into measures of spatial residential segregation is that it may change reported city-wide indices of segregation. Previous comparisons of different methods of incorporating spatial analytic techniques into research on racial inequality report mixed results. Two spatial methods have been introduced into the research literature recently. Sparks, Bania and Leete (2010) argue that access to healthy food should be measured not by straight-line (Euclidean) distance from one's home to grocery stores, but rather on how easily one can reach the grocery store based on street networks. However, that insight did not change the identification or total number of food deserts in Portland, Oregon compared to analyses based on Euclidean distance. Second, Lee and colleagues' spatial entropy scale

introduced surface density analysis to the study of segregation, as described in chapter 2. Epidemiologists have argued that incorporating Lee and colleagues' spatial measure (also referred to as Euclidean kernel density analysis), while providing more flexibility, has no significant effect on black-white segregation, especially in larger, northern cities such as Philadelphia (Kramer, Cooper, Drews-Botsch, Waller and Hogue 2010). However, Kramer and colleagues did find that incorporating the surface-density measures of segregation reveals a stronger association between segregation levels and pre-term birth rates for black mothers. Thus, while other research cautions against expecting a substantial change in city-wide measures of segregation, the work of Wong (2005; 1993) and the change in the *effects* of segregation when using surface-density as opposed to tract-based methods highlight the importance of carefully studying any measurement change in city-wide levels of segregation when introducing a methodological advance to the study of the spatial pattern of segregation. As Kramer and colleagues note, "We find that the class of surface-density-derived measures of evenness and isolation segregation proposed by Reardon [and colleagues] is highly correlated with traditional census tract-derived indices. Although reassuring, the high overall degree of correlation between measures may obscure important differences of interest..." (2010; 10)

Thus, before turning to differences within and between barriers and their roles as neighborhood boundaries in the next chapter, I computed both a special dissimilarity index and a spatial entropy index for Philadelphia following Reardon and colleagues' (2009) schema of calculating kernels with radii of 500, 1000, 2000, or 4000 meters to calculate both the micro- and macro-segregation for the city in 1990, 2000, and 2010.

These spatial scores and indexes use a Euclidean definition of space (neighbors in every direction are equally important to one subunit's observed level of segregation) are the baseline comparisons for calculating the overall effect of incorporating boundaries into city-wide measures of segregation.

Next, I calculate spatial entropy scores that incorporate the location of barriers into the analysis. Technically, this means defining space as “non-Euclidean,” as the direction impacts the effect of neighbors. In other words, those neighbors of a subunit that are located on the opposite side of a barrier have less of an impact on a unit's observed level of segregation than neighbors that are an equal distance away but are not located across any barriers. For this analysis, I define barriers as major roads (Grannis 2009; 2005), railroad tracks and elevated subway tracks (Ananat 2011), and blocks with no residential use. Non-residential blocks may be vacant spaces or may contain a variety of uses in Philadelphia including airports, industrial space, major hospitals, large schools, and commercial centers. While such sites may be locations of cross-racial interactions (for example, the Community College of Philadelphia includes buildings that are entire blocks, and it has a highly diverse student and teacher population), they also limit residential interactions across them and act as symbolic and boundaries. Because this project is focused on residential segregation and not cross-racial interactions, such geographic spaces—if they correspond to changes in racial residential demographics—are likely to act as barriers to integration or even as neighborhood boundaries. As such, any raster cell that is coded as having a population of 0 or as falling on a railroad tract or major road as defined by the Census Bureau is treated as being a barrier. All barrier types

are treated as having equal friction to each other per simulation; if roads have a friction value of 10, so do railroad tracks and non-residential spaces².

One form of non-residential land use is treated as an opportunity for integration rather than as a barrier. Parks and green spaces owned and operated by the city or state are treated as zones of potential integration (in separate analyses, such spaces were treated as identical to residential raster cells. This had no substantial effect on the analysis), due to the many different groups that use the city parks and because one such park, Rittenhouse Square, has been famous for decades as a site of both cross-class and cross-racial interaction (even as the neighborhoods surrounding it have grown more monoracially white and wealthy over the past thirty years) (Jacobs 1961; Anderson 2011).

To determine whether or not barriers affect citywide indexes, I report the results from three sets of non-euclidean kernel density analyses that include barriers with friction. For example, in a simulation in which barriers have twice the friction of non-barriers, individuals on opposite sides of a barrier have one half the impact on the entropy score of each other compared to traditional, Euclidean values such as those used by Reardon and colleagues (2009) and Lee and colleagues (2008). The three friction values

² While each individual raster cell is given an equal weight, that does not mean that barriers of different sizes have equal impacts on the surface density calculation. If a barrier is large enough to be more than one cell wide, each cell in that barrier is given the weighting as a barrier cell. For example, the wider Schuylkill River is more than 5 cells wide while running through Philadelphia while smaller water ways such as Tacony Creek are never more than one cell wide.

used are 2, 10, and 1000. Friction values were selected to represent ideal types and are not meant to imply that one value is more accurate or realistic than another. Values between 1 and 2 were picked to test the strength of barriers—if they had drastic results at the highest level of frictions, these small differences in their impact might help identify a threshold at which friction begins to have an impact on results. The 2x friction was selected because of its conceptual simplicity: it is twice as hard to cross a barrier than a non-barrier cell. The 10x friction was selected for similar reasons. Finally, the 1000x friction is designed to approximate a nearly impassable barrier: 1000 people on one side of the barrier would have the same impact as a single person on an individual on the other side of the barrier. Future work should attempt to identify the correct impact of the typical barrier in order to more accurately capture the real impact of barriers as opposed to providing a range of potential impacts, dependent on *a priori* decisions about the strength of barriers.

Results

Black/White Evenness in Philadelphia

Like other major northeastern cities, Philadelphia's population has been shifting from majority white to majority black. In 1970, for example, Philadelphia was roughly two-thirds white and one-third black and those two groups were approximately 97% of the city's roughly 2 million residents. In the last thirty years of the 20th century, Philadelphia lost almost 500,000 total residents and by 2000, the non-Hispanic black and white populations of the city were almost identical in size (42.6% and 42.5%

respectively). By 2010, Philadelphia's total population had stabilized as white and black out-migration continued while in-migration by Hispanic and Asian immigrants to the city grew. Between 2000 and 2010, the black population grew larger (or, more accurately, shrunk less) than the white population of Philadelphia. According to the 2010 census, non-Hispanic black residents made up 42.2% of the population of the city compared to 36.9% non-Hispanic white.

In short, across the three censuses used in this dissertation, Philadelphia's black and white populations changed from a high of 825,839 white residents and a low of 623,510 black residents in 1990 to 625,662 white residents and 662,287 black residents in 2010. Thus, these three decennial censuses provide a unique opportunity for examining the effect of incorporating barriers into measures of citywide segregation between the black and white populations in a city with a majority white population (1990), a 50/50 split of white and black residents (2000), and a majority black population (2010). Extralocal and larger demographic shifts in the black and white residential population of a neighborhood or city have been shown to affect overall levels of segregation in previous research (Crowder and South 2007), and looking at all three decades may identify changes in the impact of physical geography on racial geography that correspond to shifts in the racial demographics of the city.

I begin by comparing the four dissimilarity measures in 1990, 2000, and 2010: one in which there is no friction at the barriers identical to the methods used by Reardon and colleagues (2009), one in which barriers have twice the friction as non-barriers (in other words, individuals on the same side of a barrier have twice the impact on an area's

demographics than individuals on the opposite side of the barrier), one in which barriers have ten times the friction, and one in which barriers have 1000 times the friction. Each raster cell's kernel (the circular area around the cell of interest used to calculate that cell's racial demographics) is measured at four sizes. The smallest has a radius (also known as a "bandwidth") of 500 meters and is comparable to an easily walkable neighborhood in any direction, unless there is a barrier. The second smallest radius is 1000 meters or 1 kilometer in each direction and is a larger but still walkable area. The two larger neighborhoods—2000 meters and 4000 meters in radius—are included for those people who use cars to travel their neighborhoods, because the previous research using kernel density analysis to measure segregation profiles uses them, and because prior research (Bader and Ailshire 2010) indicates that even at these distances, the racial composition of the population is associated with residential senses of fear or safety in their neighborhood.

Looking first at the replication of the methods used by Reardon and colleagues (2009) and Lee and colleagues (2008), I find that Philadelphia is hypersegregated with regard to evenness. At the smallest definition of a neighborhood, the black-white dissimilarity ranges from 0.785 at its highest point in the 1990 decennial census to a low of 0.750 in 2010. Unsurprisingly, as research into the modifiable areal problem shows, defining the neighborhood in progressively larger terms led to progressively lower observed levels of segregation. At the 1000 meter neighborhood definition, dissimilarity drops almost 0.03 points in 1990 and by over 0.01 points in both 2000 and 2010. This

Table 4.1 Black-White Dissimilarity Index by Neighborhood Radius and Friction Levels

	Friction level	500 Meter radius	1000 Meter radius	2000 Meter radius	4000 Meter radius	
	D	% Difference from Euclidean Value	D	% Difference from Euclidean Value	D	% Difference from Euclidean Value
1990	None	.785	.759	.735	.711	
	2x	.785	.758	.734	.713	.002813
	10x	.797	.783	.750	.717	.008439
	1000x	.77	.752	.755	.830	.169900
2000	None	.784	.771	.755	.733	
	2x	.783	.770	.754	.737	.005457
	10x	.802	.796	.779	.754	.028649
	1000x	.81	.784	.741	.701	-.043242
2010	None	.750	.738	.723	.702	
	2x	.749	.736	.721	.702	.000000
	10x	.762	.753	.735	.709	.009972
	1000x	.771	.777	.774	.771	.101551

impact of the neighborhoods' size continues at both the 2000 meter radii neighborhoods and the 4000 meter radii, to the point that the dissimilarity in 2010 at 4000 meters is barely above 0.70.

Across all three census periods, making barriers have twice the “friction” of residential spaces never has even a 1% effect on the observed level of segregation in Philadelphia. Setting the friction at barriers to 10 times that of residential spaces only occasionally reaches a 3% effect on the observed level of segregation. In short, if barriers are associated with racial space but are not entirely predictive of racial boundaries, then including them in the measurement of citywide segregation levels should have had a more significant effect. It is possible, however, that barriers are also stronger boundaries between neighborhoods. Specifically, it may be that any major road or river not only makes it less likely that individuals living near each other are in the same neighborhood, but that it makes it virtually impossible. The final row for each census reports the results of simulations in which barriers have 1000 times the friction of non-barriers, effectively rendering the barriers impassable. In this final row, barriers have little effect on segregation in 1990 and 2000, aside from a 16.7% impact at the 4000 meter radius in 1990. That outlier is likely due to the impact of the suburbs that I discuss after comparing the dissimilarity scores to entropy-based scores. Finally, in 2010, we see the first consistent impact of including impassable barriers. The barriers keep dissimilarity constantly between 0.771 and 0.777 across all four radii, while the models without barriers sees the dissimilarity score drop from 0.750 at 500 meters to 0.702 at 4000 meters. As such, the inclusion of barriers leads to a 10% increase in the measured

“macro-level” segregation at the 4000 meter neighborhood definition. Overall, however, barriers do not appear to have a substantial impact on black-white evenness.

A more longitudinal examination of the results identifies some impact of barriers on segregation. In the replication of previous work, segregation was roughly stable at the 500 meter radius between 1990 and 2000 before falling between 2000 and 2010. At the larger neighborhood definitions, segregation actually grew in Philadelphia between 1990 and 2000 when Philadelphia’s population as a whole was still shrinking before falling more dramatically between 2000 to 2010 to reach their lowest points in the most recent decennial census. In the simulations with barriers that were 1000 times as strong as residential spaces, however, the pattern is slightly changed. At the smallest neighborhood definition, segregation grew between 1990 and 2000 before dropping in 2010 back to the same level as 1990, never falling below the results from 1990. At the 1000 meter radius, segregation again grew before 2000 and while it fell in 2010, it did not even fall back to the same level as in 1990. At the 2000 meter radius, however, segregation *fell* in the 1990s before climbing between 2000 and 2010. Finally, at the largest radius, segregation fell dramatically between 1990 and 2000 (from 0.830 to 0.701) and then grew nearly as dramatically (from 0.701 to 0.770). While barriers, within each individual decennial census, have relatively small impacts on black-white segregation, over time, those impacts combine together to provide substantially different analyses of trends in segregation in Philadelphia. Without barriers, it appears to be a simply story in which segregation remained relatively stable before falling. However, the inclusion of barriers

led to segregation appearing to grow substantially between 1990 and 2000 before falling in 2010, though how far it fell depends on how one defines a “neighborhood.”

Next, I measure the black-white entropy index for those four same friction levels. Before turning to the results, it is important to note two impacts of studying entropy instead of dissimilarity. First, while the entropy levels appear lower than the widely reported dissimilarity levels for Philadelphia, this is because the entropy index is typically lower than the dissimilarity index. That is, while hypersegregation traditionally is measured with a cut-off of 0.600 on multiple measures including the dissimilarity index (Massey and Denton 1989), entropy index values rarely reach .6. Philadelphia, for example, had dissimilarity scores of 0.768 and 0.720 in 1990 and 2000 respectively (census: http://www.census.gov/hhes/www/housing/housing_patterns/tab5-4.html). Alternatively, entropy scores for the same years are 0.630 and 0.620, respectively. These scores are virtually identical to the values calculated by Lee and colleagues (2008)³. Second, entropy is calculated using a logarithmic transformation. Therefore, the entropy score (and subsequent entropy index) is a non-linear calculation of evenness. For example, a neighborhood with a population that is 10% black and 90% white has an

³ The small difference in calculation between my spatial entropy index and Lee and colleague’s is that I calculated the measurement for only Philadelphia County as opposed to the entire Philadelphia metropolitan region (I use the surrounding counties to calculate the surface densities but then remove all non Philadelphia areas before calculating the entropy index). If anything, it is striking how similar the two calculated values are, likely due to the fact that over 80% of the metropolitan region’s Black population lives in Philadelphia County.

entropy score of 0.325. Increasing the black percentage to 20% increases the entropy score to .50, an increase of 0.175. However, changing from 20% black to 30% black only results in an entropy score increase of 0.110. In other words, the non-linearity of the entropy score formula emphasizes the effect of increasing small minority populations while de-emphasizing the effect of increasing larger minority populations.

Overall, when looking at black-white evenness via the entropy index instead of the dissimilarity index, incorporating barriers into the analysis still have only a small effect. However, that effect is much more variable. In these simulations in which boundaries are effectively equivalent to walls between neighborhoods, there is a stronger, albeit variable, effect on observed levels of black-white segregation. In 1990, at the 1000 meter radius, the simulations with the impassable boundaries report a nearly 10% *decrease* in the overall segregation in Philadelphia. However, at the 2000 meter radius, I find the same 10% effect—only at this radius, the effect is positive: including the barriers increases segregation in Philadelphia. At 4000 meters, segregation decreases almost 14% when impassable barriers are included. Effects are even smaller in 2000 and 2010. Other than one result in 2010, the effects of including barriers on the entropy index—with any friction value—routinely has a negligible effect on overall levels of segregation. The inconsistency of the impact of almost impassable barriers on measures of evenness highlights the problems of the non-linearity of the entropy score. With a linear measure of evenness, such as dissimilarity, including barriers can mathematically only lead to a higher observed level of segregation because every individual person is always counted equally in terms of their impact on the total population's level of evenness. The non-

Table 4.2 Black-White Entropy Index by Neighborhood Radius and Friction Levels

Friction level	500 Meter radius	1000 Meter radius	2000 Meter radius	4000 Meter radius					
	Entropy Index	% Difference from Euclidean Value	Entropy Index	% Difference from Euclidean Value	Entropy Index	% Difference from Euclidean Value	Entropy Index	% Difference from Euclidean Value	
1990	None	.6265		.5868		.5491		.5102	
	2x	.6181	-0.01341	.5793	-0.01278	.5434	-0.01038	.5116	0.002744
	10x	.6069	-0.03128	.5835	-0.00562	.5586	0.017301	.522	0.023128
	1000x	.6278	0.002075	.5285	-0.09935	.6078	0.106902	.4408	-0.13603
2000	None	.6212		.6004		.5732		.5393	
	2x	.6195	-0.00274	.5993	-0.00183	.575	0.00314	.5471	0.014463
	10x	.6383	0.027527	.6234	0.038308	.5991	0.045185	.5448	0.010198
	1000x	.6379	0.026883	.611	0.017655	.5627	-0.01832	.5031	-0.06712
2010	None	.5609		.5419		.5188		.4865	
	2x	.5543	-0.01177	.534	-0.01458	.5128	-0.01157	.4858	-0.00144
	10x	.5597	-0.00214	.5405	-0.00258	.4932	-0.04934	.4627	-0.04892
	1000x	.5531	-0.01391	.533	-0.01642	.3502	-0.32498	.4866	0.000206

linearity of the entropy score, however, means that changes in areas with small minority populations will have a larger impact on the entropy index than those in areas with more diverse populations⁴.

These seemingly inconsistent results also may indicate the impact of including the predominantly white suburbs into the calculation. When computing the population estimates for each cell's kernel value, I included the suburbs surrounding Philadelphia in the kernel density analysis but did not include them when calculating Philadelphia's entropy index in order to avoid edge effects on my calculations (Bailey and Gattrell 1995). That is, while the predominantly white suburbs are included in calculating residential surface density, the level of segregation within the suburbs is excluded from the analysis of those surface densities⁵. As such, those areas of the map on the edge of

⁴ This is particularly problematic for smaller populations that are highly clustered, such as the Asian and Hispanic populations of Philadelphia and is another reason why I use dissimilarity instead of entropy to measure their levels of segregation and the impact of physical barriers. As the United States grows more diverse, it is important that sociologists create an improved multigroup measure of segregation that does not have the linearity problem discussed here.

⁵ This was done for three reasons. First, the suburbs are overwhelmingly white and including them would potentially overwhelm the impact of barriers within the city of Philadelphia. Second, barriers (and especially roads) may function differently in a city with an urban core and significant access to public transportation compared to suburbs. Third, running the analyses for only the city was computer-intensive. Expanding to include the suburbs would have greatly expanded the amount of space and raster cells in the calculation for little net benefit.

Philadelphia are affected by the suburbs⁶. In the case of the barriers, different suburbs are differently bounded by barriers. For example, Camden, a large, predominantly black urban area, is located directly across the Delaware River from a section of center city (Society Hill and Old City) that is predominantly white. Once I include barriers in the analysis, Camden would no longer influence the results in Old City or Society Hill, rendering them more segregated in the new simulation. On the other hand, the suburbs near largely black West Oak Lane are predominantly white and not bounded by barriers like the Delaware River. As such, those suburbs can continue to have an integrative effect on the citywide measure, even after including barriers. Further, most of the neighborhoods near the edges of Philadelphia that are not bounded by barriers (mostly located in the Northeast section of the city) are disproportionately white, so the population “loss” from the more densely populated city into the less dense suburbs, via the kernel density function, may have a larger net negative effect on the white population of Philadelphia than on the black population. This highlights the importance of looking not only at citywide levels of segregation, but also the *geographic patterns* of segregation

⁶ In addition, these edge effects also explain one way in which segregation can appear lower in a two-group measurement after incorporating boundaries. In a hypothetical space in which the edges have *no* effect on the kernel density function, incorporating “friction” barriers into the kernel density analysis can only serve to heighten segregation between those two populations (this is not true for a multigroup analysis). However, in a case where the integrated areas of a city are bounded on all sides by barriers while the highly segregated areas of the other group are not bounded by barriers it is possible that the unequal loss of population from segregated areas but not from integrated areas would then lead to a smaller observed level of segregation.

in the city, which is the focus of a later section. Before jumping to local patterns of segregation, however, it is instructive to compare the findings on black-white segregation to similar analyses including Hispanic and Asian residents to determine whether or not the findings reported above are unique to the hypersegregation between black and white residents or are more broadly applicable to residents of Philadelphia.

For whom the Boundary Matter: Considering Asians and Hispanics

As the previous section shows, incorporating barriers into the measurement of segregation has only a small effect on our understanding of black-white evenness. Most likely, two methodological limitations are simultaneously at work at the same time. First, when studying a two-group index of segregation, incorporating barriers (assuming no edge effects) can only lead to a higher level of reported segregation. Second, Philadelphia is already hypersegregated and thus a ceiling effect may be limiting the observed change in citywide measures of segregation. In other words, if Philadelphia is hypersegregated even before including a variable that should show higher levels of segregation, how much more segregated can it become?

Including Hispanic and Asian residents of Philadelphia resolves both of these concerns. Philadelphia's Hispanic and Asian populations, as is generally true in the United States (Charles 2003; Iceland 2009), are substantially less segregated than its black population. A comparison of Tables 4.2 and 4.3 shows that the multigroup entropy index for Philadelphia without barriers is consistently between 0.100 and 0.150 lower

than the black-white entropy index. As such, we can be confident that the ceiling effect seen with black and white segregation is not a concern in the multigroup entropy index.

With regard to the second concern that barriers can only lead to higher reported segregation (again, excluding edge effects), by including more than two groups, barriers can now enhance the integration of some areas by effectively shielding a less dense but highly integrated area from being masked in the entropy index by a neighboring, highly segregated and extremely dense population area. For example, imagine an overwhelmingly black neighborhood that consists of large, multiunit apartment buildings. This neighborhood is situated across a major road from a neighborhood that is largely single-family detached houses with a more integrated Asian and white population. Using the spatial entropy index without barriers, the black population may overwhelm the more integrated but less dense Asian/white population and both areas might appear disproportionately black and highly segregated. However, if we include the barrier as a boundary, the black population would continue to appear highly segregated *but only in their original neighborhood* while the Asian/white area would now appear to be significantly more integrated than previously, lowering the entropy index for the entire city.

Turning more closely to Table 4.3, results suggest that barriers have only minimal on the entropy index in 1990. This is unsurprising as only 5% of Philadelphia's population in 1990 was Asian or Hispanic. As such, including Asian and Hispanic residents had relatively small effects on the entropy index, which only dropped by .1 relative to the two-group entropy index (a roughly 12% decrease). In addition, including

Table 4.3 Multigroup Entropy Index by Neighborhood Radius and Friction Levels

Friction level	500 Meter radius		1000 Meter radius		2000 Meter radius		4000 Meter radius	
	Entropy Index	% Difference from Euclidean Value	Entropy Index	% Difference from Euclidean Value	Entropy Index	% Difference from Euclidean Value	Entropy Index	% Difference from Euclidean Value
1990	None	.5195			.484		.4508	
	2x	.5134		-0.01174	.4792		.4486	
	10x	.4582		-0.118	.4792		.4384	
	1000x	.4716		-0.0922	.5027	0.03863	.4638	
2000	None	.4716			.453		.4313	
	2x	.4688		-0.00594	.4556		.4337	
	10x	.4556		-0.03393	.4387		.4166	
	1000x	.38		-0.19423	.3096		.1839	
2010	None	.4003			.387		.3713	
	2x	.3991		-0.003	.3855		.3672	
	10x	.4031		0.006995	.3712		.351	
	1000x	.3231		-0.19286	.3716		.2014	

barriers in the calculation also has a minor impact on the entropy index, regardless of the distance and relative weight of the boundaries. With a 500 meter kernel, including barriers at 1000x the “friction” of residential areas had decreased the observed entropy level by 9%, from 0.52 to 0.47. The only other potentially meaningful effects of friction came at the largest radius of 4000 meters, in which it improved the observed entropy level by 9% with 10x friction barriers, had a small segregating effect with the nearly impassable 1000x friction barriers.

By 2000, however, Philadelphia had experienced substantial immigration from Asia and Latin America, with Asians and Hispanics totaling over 10% of Philadelphia population for the first time. As such, it comes as little surprise that incorporating them into the entropy index has a larger effect than in 1990. In 2000, the observed entropy index without barriers dropped 0.15 when compared to the two-group entropy index, a drop of roughly 25%. In addition, and much more substantial, including barriers in the calculations now has a larger and more consistent effect on the observed levels of entropy. Barriers have little effect on the observed level of segregation at the double and 10x friction values. However, at the nearly impassable barrier level, the 1000x friction, there are substantial effects at all four neighborhood radii. In all four cases, including the impassable barriers has a large integrative impact. The entropy index drops by 20% at the smallest neighborhood definition, by 30% at the 1000 meter radius, and by over 50% at both the 2000 and 4000 meter radius. In sum, once the Asian and Hispanic populations grew into sizable proportions of Philadelphia’s total population, Philadelphia’s total entropy level was lower than the comparable black/white entropy level as those racial and

ethnic minorities are more integrated than black residents in the area. However, above and beyond that finding, the observed level of segregation *overall* is substantially improved with the inclusion of highly impassable barriers.

By 2010, the Asian and Hispanic populations totaled well over 17% of the population of Philadelphia. Unsurprisingly, including them into the entropy index again had a substantial impact of over 0.15 for every radius. Including barriers had little effect on the entropy index until they were weighted as nearly impassable. Once again, barriers had a large integrative effect, but one that was somewhat smaller than in 2000. At 500 meter radii, in both 2000 and 2010, the impassable barriers decreased the entropy index by just under 20% compared to an entropy index that had no barriers. At 1000 meters, however, barriers had no substantial effect in 2010 (only a 4% decrease) as opposed to 2000 when there was an over 30% decrease in observed segregation at the 1000 meter radius. At the larger radii, the barriers again had large effects in 2010, but these effects were substantially smaller than in 2000. For example, at the 4000 meter radius, the entropy index in 2000 fell more than 50% from its level in 1990, and in 2010 it dropped 32% from its level in 2000. Some of that difference in the impact of barriers is due to the substantially lower starting point. In 2010, the entropy index at 4000 meters was under 0.35 but it was over 0.40 in 2000. In general, while the magnitude of the change in observed segregation associated with accounting for barriers fell, the pattern was consistent. Unlike for black-white entropy, once there were substantial Asian and Hispanic populations in Philadelphia, incorporating impassable barriers into the measurement of the city's segregation profile made Philadelphia appear substantially less

segregated than more traditional measures that did not include barriers in the calculation of Philadelphia's entropy index.

As the earlier hypothetical neighborhoods make clear, it is important not only to look at the effect of barriers on the citywide entropy index, but also to study exactly where the localized changes in entropy occur. That is, while the entropy index is dramatically lower once I include Asian and Hispanic residents and barriers into a multigroup measure of segregation, it may be the case that the changes observed—and the change in the impact of barriers—may be unique to specific areas of the city. One of the flaws of the multigroup entropy index is that it treats all forms of racial and ethnic integration as equal. In a city such as Philadelphia that has almost equal white and black populations with few Asian and Hispanic residents, an area that is 50% white and 50% Asian has the same entropy score and impact on the entropy index as an area that is 50% white and 50% black, even though the second area is more realistically integrated with respect to Philadelphia's total population. All ethnic and racial groups, arguably, should not be weighted equally, but the entropy index requires that they be treated as equal. The integration of Asian immigrants into white neighborhoods and Hispanic immigrants into black neighborhoods may appear to lower measured levels of segregation, however, with respect to segregation's negative effects on neighborhood quality and individual outcomes for blacks and Hispanics in Philadelphia⁷, the lower level of total segregation

⁷ Philadelphia's Hispanic population is predominantly Puerto Rican, a group that has historically been subjected to racial and ethnic discrimination and exposed to disadvantaged neighborhoods at levels much

may be a mirage that obscures the persistent effects of sustained segregation within Philadelphia.

Unfortunately, while the multigroup entropy values show that barriers do have an effect on segregation, it is unclear which racial groups combination is being affected by those barriers. One way to do so is to compare the impact of barriers on different combinations of two racial groups. Table 4.4 does so for dissimilarity scores in 2010. Before studying the impact of barriers, Asian and Hispanics are substantially less segregated from whites than blacks are, as is true across the country generally (Iceland and Scopelitti 2008; Charles 2006). Nonetheless, the Hispanic population in Philadelphia is still hypersegregated from whites. This is likely in part due to the large Puerto Rican and Dominican populations within the Hispanic population in the city, ethnicities that are more likely to be racially black and are generally more segregated than white Hispanic groups such as Cubans or Mexicans. Black residents of Philadelphia are also hypersegregated from both the Asian and Hispanic populations of Philadelphia, which are not similarly hypersegregated from whites. Hispanics and Asians do not reach the 0.600 cut-off for hypersegregation, though they are very close.

Turning to the impact of barriers, we see that white-asian segregation is substantially impacted by barriers. At the smallest definition of the neighborhood, Asian-white dissimilarity is 0.483 without barriers and 0.521 with the nearly impassable

higher than other Hispanic immigrants in the United States (Wahl, Breckenridge, and Gunkel 2006; South, Crowder, and Chavez 2005; Santiago and Galster 1995)

Table 4.4 Two-Group Dissimilarity Index by Neighborhood Radius and Friction Levels

Friction level	500 Meter radius		1000 Meter radius		2000 Meter radius		4000 Meter radius	
	D	% Difference from Euclidean Value	D	% Difference from Euclidean Value	D	% Difference from Euclidean Value	D	% Difference from Euclidean Value
white-Asian	None	.483	.465	.445	.420			
	2x	.488	.471	.454	.428			
	10x	.504	.502	.488	.483			
	1000x	.521	.515	.479	.445			
white-Hispanic	None	.623	.613	.600	.582			
	2x	.634	.626	.613	.598			
	10x	.638	.631	.62	.607			
	1000x	.634	.632	.633	.624			
black-Asian	None	.678	.663	.643	.618			
	2x	.676	.661	.644	.619			
	10x	.681	.676	.667	.640			
	1000x	.684	.689	.693	.672			
black-Hispanic	None	.654	.647	.638	.625			
	2x	.655	.649	.640	.631			
	10x	.672	.669	.660	.655			
	1000x	.659	.654	.643	.622			
Hispanic-Asian	None	.575	.566	.555	.541			
	2x	.574	.565	.557	.547			
	10x	.576	.573	.572	.567			
	1000x	.578	.578	.582	.604			

barriers. That difference continues at the larger radii as well, except for the 4000 meter radius, which may be impacted by the immigration of educated Asian immigrants directly or almost directly into the suburbs, instead of into the urban core (Alba, Logan, Stults, Marzan and Zhang 1999; Waters and Jimenez 2005). Similar sized differences of 0.05 persist when measuring the impact of boundaries on black-Asian dissimilarity and smaller, and barriers have smaller but still over a 5% impact on black-Asian segregation at the larger neighborhood definitions. On the other hand, we see that barriers have next to no effect on black-Hispanic segregation. That is, the segregation between those two groups is not structured by the existence of barriers between them. Hispanic-Asian segregation shows an interesting pattern as barriers never have higher than a 5% impact on that dissimilarity score until we turn to the 4000 meter neighborhood definition, again, likely due to the impact of immigration directly to the suburbs on the index.

Overall, barriers have variable impacts on segregation. Whites and Asians live near each other but are often bounded by barriers, so much so that even the 10 times friction simulations had substantial impacts on the dissimilarity index and at the smallest neighborhood definitions. Asians and Hispanics are not hypersegregated and their segregation is not defined by barriers, unlike whites and Asians. Blacks and Asians are very segregated, but that segregation is not defined by major barriers except at the extremes. On the other hand, blacks and Hispanic segregation is not impacted by barriers at all: while they live separately from each other, that separation appears not to be consistently associated with major roads or other barriers.

At first glance, it appears the multigroup entropy and two-group dissimilarity results are mutually exclusive. On the one hand, it is possible that barriers promote integration by shielding integrated areas from being overrun in calculations by nearby, highly segregated areas as the multigroup entropy results indicate. On the other hand, the two-group dissimilarity scores provide evidence that barriers have small but consistent effects, and when they do, it is mostly to shield more privileged groups from blacks and to allow Asian immigrants close to whites, but on opposite sides of barriers. Mapping population densities and entropy scores can help adjudicate between the two possibilities presented by citywide indices.

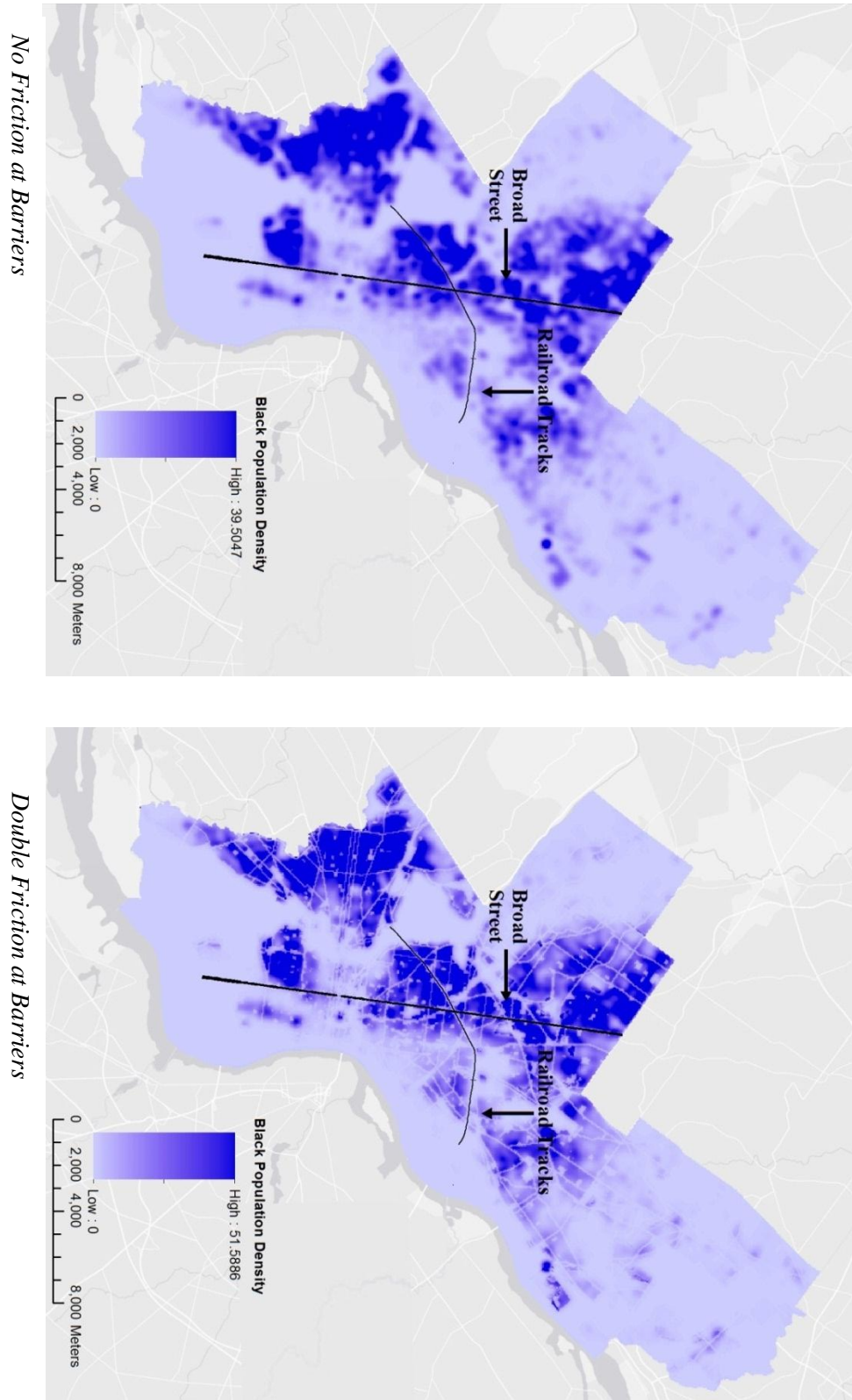
Mapping Population Densities in 2010

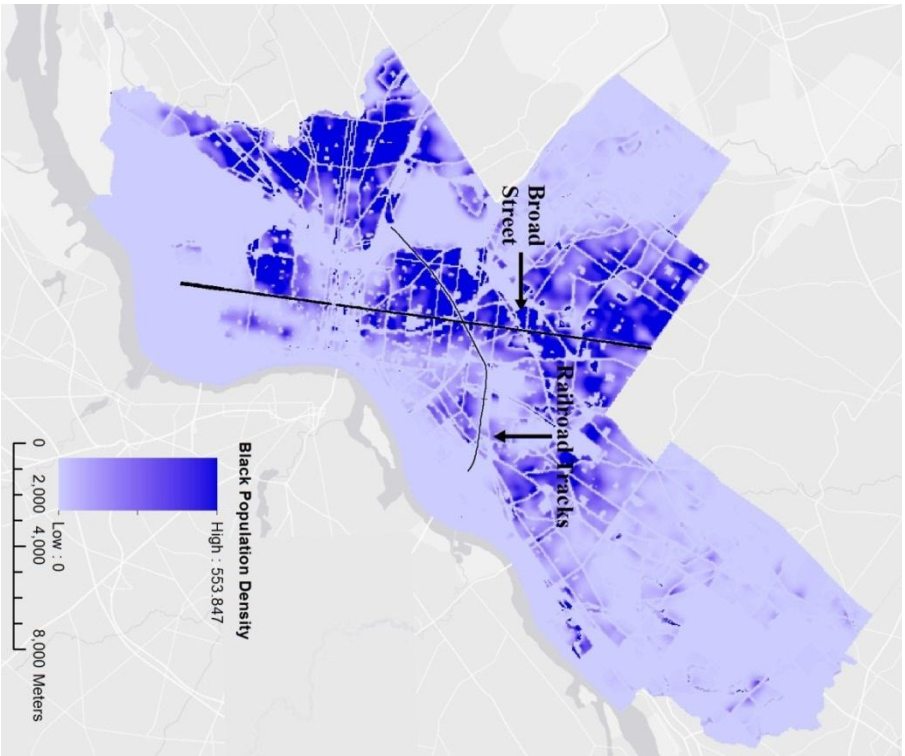
Indexes such as entropy or dissimilarity are useful to summarize a large pattern for a city, but in doing so they can also obscure the local realities of segregation. For a resident of University City in West Philadelphia, the hypersegregation of Northeast Philadelphia has no significant direct impact on his/her experience of segregation. For a society, it is important to grapple with city, regional, and even national levels of segregation to measure and describe racial inequality and separation. For individual residents and targeted policy initiatives, it is more important to identify the local, neighborhood patterns of segregation to focus efforts to promote integration, provide better access to services or, at the bare minimum, attempt to mitigate the negative consequences of segregation on individual-level health, wealth, and other important outcomes.

Figure 4.1 is a set of three maps of the black population of Philadelphia in 2010. On the left is a Euclidean surface density, that is, a map without any barriers included (neighborhood radius = 500 m) of the black population. The middle is a non-Euclidean surface density map in which barriers have double the friction as residential land. The third map is a non-Euclidean surface density map in which barriers have frictions that are 1000 times greater than residential land. Each map shows the hypersegregation of Philadelphia: the black population of Philadelphia is overwhelmingly concentrated in West and North Philadelphia, even before including barriers. In fact, at 500 meter kernels, the location of barriers is visible, including the SEPTA tracks that run through North Philadelphia, Broad Street, and the barriers between the gentrifying Graduate Hospital Area and the poorer area of Newbold/Point Breeze. Turning to the map in which barriers have double friction, the barriers' effects are significantly more visible, and sharper outlines exist between the largely white areas of Philadelphia and the largely black areas. The third map, in which barriers are practically impassable, shows no significant difference visually from the second map except to sharpen the divides already made visible in the map with doubled friction.

It is important to also consider the legend on these three maps. While the color scheme in each map is identical, the value represented by darker or lighter blues changes with each map. Doubling the friction also leads to a larger maximum density per 50x50 meter cell, from just less than 40 black residents in the Euclidean map to over 51 residents in the double-friction map. The third map, with 1000x the friction, has a maximum value of over 550 residents per cell, a density typical of large apartment

Figure 4.1 Impact of Physical Barriers on Black Population in Philadelphia in 2010, 500 Meter Radius, Various Levels of Friction





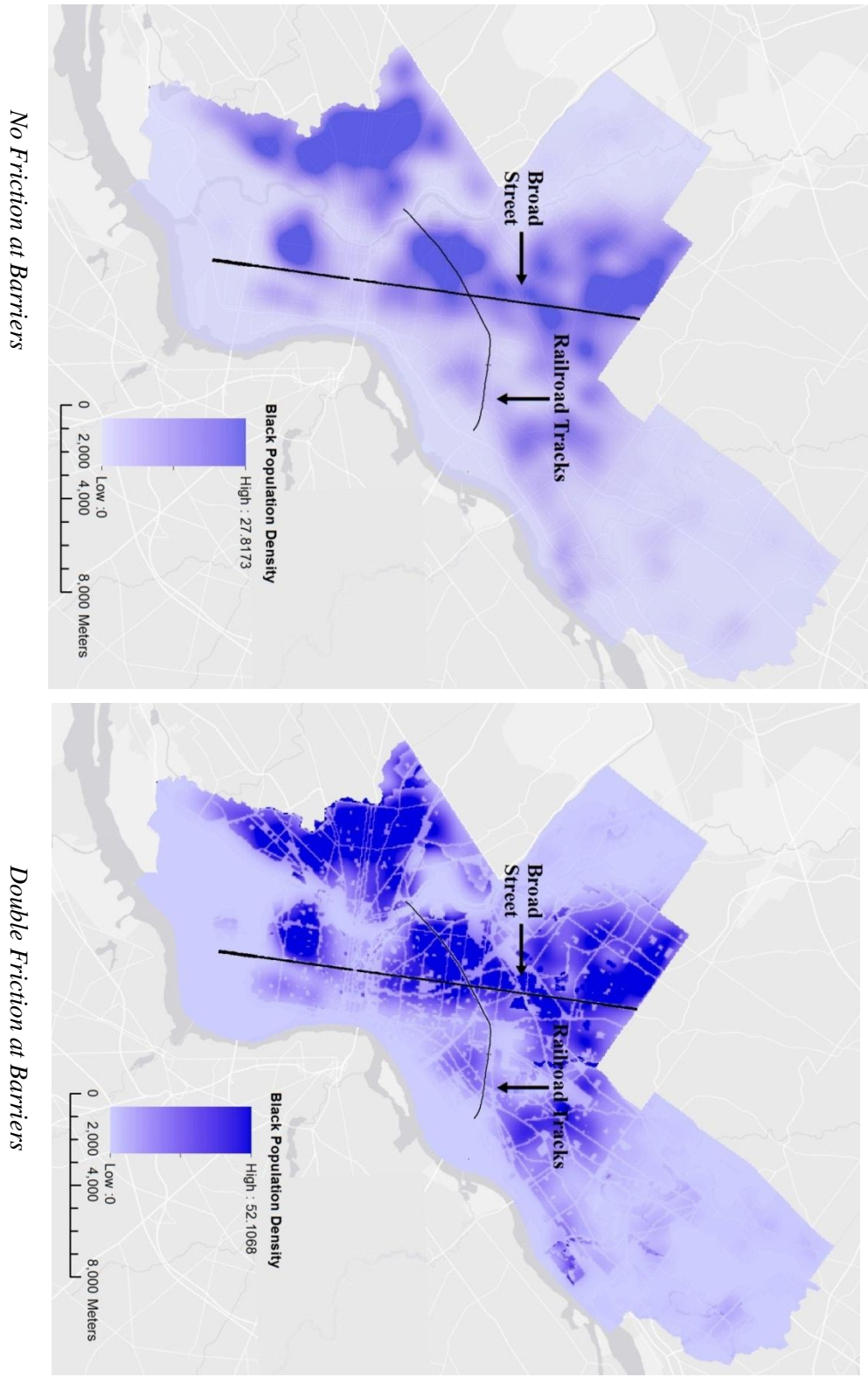
1000x Friction at Barriers

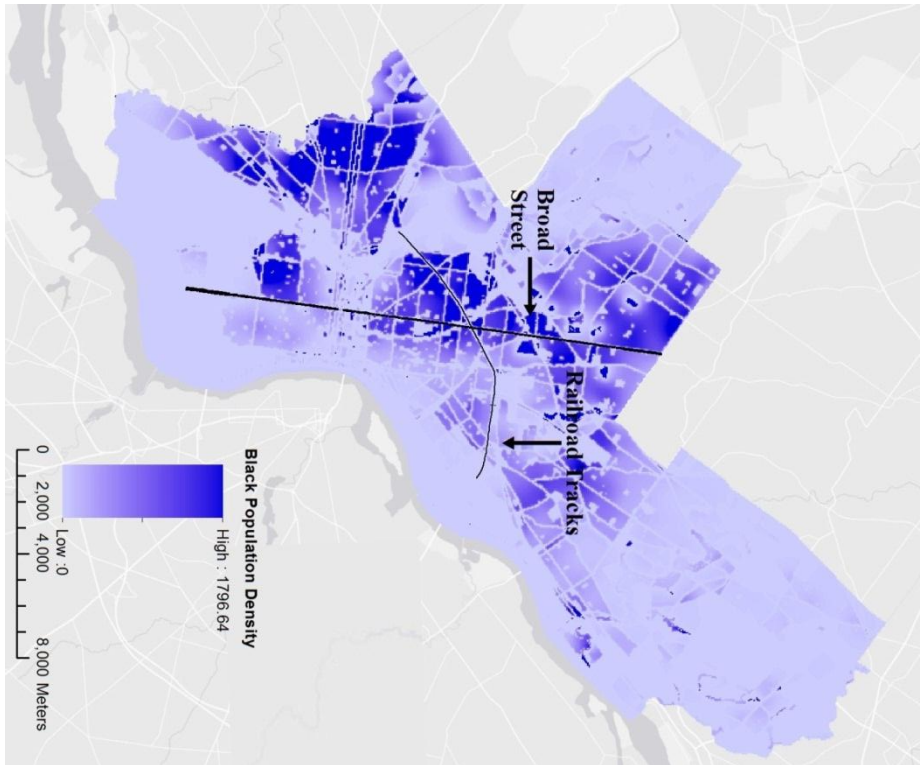
complexes before smoothing the data using kernel density analyses⁸. While the impact of barriers on segregation becomes clear in the map with doubled friction at the barriers, the extent of that segregation is most clearly represented in the extreme density reached by incorporating more substantial barrier effects. Nonetheless, that even a small part of Philadelphia's black population is that isolated due only to the incorporation of barriers into the analysis offers a critical insight into the extent and location of racial isolation in the city.

Figure 4.2 is the same comparison of the black population's location in Philadelphia, except the kernel's radius is increased to 4000 m. In the first map, the hypersegregation—even with the extreme data smoothing of a 4000 meter neighborhood radius—is still apparent, but has lessened substantially when compared to the maps discussed previously. In addition, the maximum value for black population density has fallen from nearly 40 to just under 28 residents per cell. These slight positive signs at the macro-level of segregation (Reardon et al. 2009), however, are much weaker once barriers are included at double friction. Including barriers has two effects. First, potentially integrated areas in between white and black segregated neighborhoods such as

⁸ In at least two cases, the extreme density is caused by the large and extremely segregated prison facilities in the city, highlighting in an unexpected way, the extreme racial inequality in the criminal justice system. Previous research on segregation would either treat these facilities as included in nearby residential neighborhoods or exclude them entirely, neither of which is an ideal representation of the impact of prison-based inequality on racial segregation in a city.

Figure 4.2. Impact of Physical Barriers on Black Population in Philadelphia in 2010, 4000 meter radius





1000x Friction at Barriers

in Northeast Philadelphia now appear to be more sharply racially divided neighborhoods easily defined by barriers. Second, the maximum value for black population density has caught up with the earlier map: each map's highest black population density is about 52 residents per cell. The final map, in which barriers are again practically impassable, is indistinguishable from the previous map. However, the maximum population density is triple that of the same map with a 500 meter neighborhood radius: the densest parts of Philadelphia reach as high as nearly 1800 black residents per cell compared to 550 per cell at the smaller radius.

Mapping Border Effects

Given the finding that incorporating barriers has no consistent or substantive effect on citywide patterns of segregation at the neighborhood or macro-level, it may seem that incorporating barriers has little impact on measuring segregation, just like changing from census tract aspatial measures to the spatial entropy index had little impact on measured levels of segregation (Kramer et al. 2010). However, it is possible that the unchanged citywide results mask more localized changes at or near the barriers. The previous section and accompanying maps suggest that barriers have this effect—they have localized effects but do not dramatically change the reality of hypersegregation for black residents. That is, individual barriers may have a segregating effect in one direction and “protect” an integrated area in the other direction. As such, the total level of segregation in both directions may not appear to change but its location would switch: one side of the barrier would be substantially more segregated, while the other side would

become substantially more integrated. On the other hand, it is possible that the non-findings reported above are because barriers are not at all related to local levels of segregation and, as such, are more often located between two black neighborhoods (or two white neighborhoods). If this is the case, barriers have no impact on the entropy index because they are actually not associated with localized segregation.

Mathematically, if the incorporation of boundaries has the first effect described above, there should be greater variability between each individual cell's entropy score and the score for the entire city. In other words, the standard deviation should be higher for analysis with barriers. Table 4.5 illustrates this point by comparing the standard deviation for each analysis shown in Table 4.2. As expected, larger radii are associated consistently with lower standard deviations as kernel density analysis is a form of data smoothing over an area and should therefore decrease variability. 1990 is generally an exception. The simulations with the smallest radius also have the lowest standard deviations. Similarly, in 1990, there is little difference in the standard deviations attributable to barrier strength and where there are differences they are in the opposite of what would be expected. The standard deviations in the simulations for 1990 with no barriers incorporated show more variability across the entire city in entropy score than the standard deviations for those simulations with barriers of any friction. As with the entropy index results discussed above, these unexpected results may be a side effect of hypersegregation combined with edge effects. Philadelphia's racial borders generally correspond with barriers, including waterways and major roads. The one main exception is in the northeast, an overwhelmingly white area that saw dramatic population loss and

Table 4.5 Standard Deviation of Black-White Entropy Score by Neighborhood Radius and Friction Levels

Friction level	500 Meter radius	1000 Meter radius	2000 Meter radius	4000 Meter radius
	Entropy Score Standard Deviation	Entropy Score Standard Deviation	Entropy Score Standard Deviation	Entropy Score Standard Deviation
1990				
None	.240	.247	.249	.245
2x	.240	.246	.249	.245
10x	.238	.244	.247	.246
1000x	.236	.242	.246	.245
2000				
None	.231	.223	.222	.217
2x	.231	.227	.222	.218
10x	.231	.228	.224	.220
1000x	.232	.229	.226	.223
2010				
None	.224	.222	.213	.203
2x	.230	.222	.214	.203
10x	.225	.224	.217	.209
1000x	.227	.227	.221	.216

racial transitioning only after 1990. As such, in 1990 edge effects on the entropy score and its standard deviation will be localized mostly in the northeast where they affect a nearly monoracially white population.

In 2000 and 2010, however, I find the predicted pattern of standard deviations. Higher friction for barriers is associated with higher standard deviations, indicating more variability across the entire city. In addition, and supporting the hypothesis above, the standard deviations consistently drop as the neighborhood radius expands. More importantly for that hypothesis, as the bandwidth increases, the difference between the standard deviations *grows* as well. For example, in 2010 the difference between the standard deviations for entropy scores without barriers and those with barriers with the highest friction barriers only 0.003. However, that difference grows to 0.005 when the radius is doubled, to 0.007 with a neighborhood radius of 2000 meters, and to 0.013 with a radius of 4000 meters. Overall, the standard deviations for the analyses that lack barriers drop by over 0.021 across those four neighborhood radii. The same comparison for the highest friction value only drops by 0.110 across the four neighborhood radii. This result reinforces the hypothesis that barriers have an effect on segregation patterns, as the larger the definition of an egocentric neighborhood, the more raster cells that include a barrier(s) in their neighborhood population estimate.

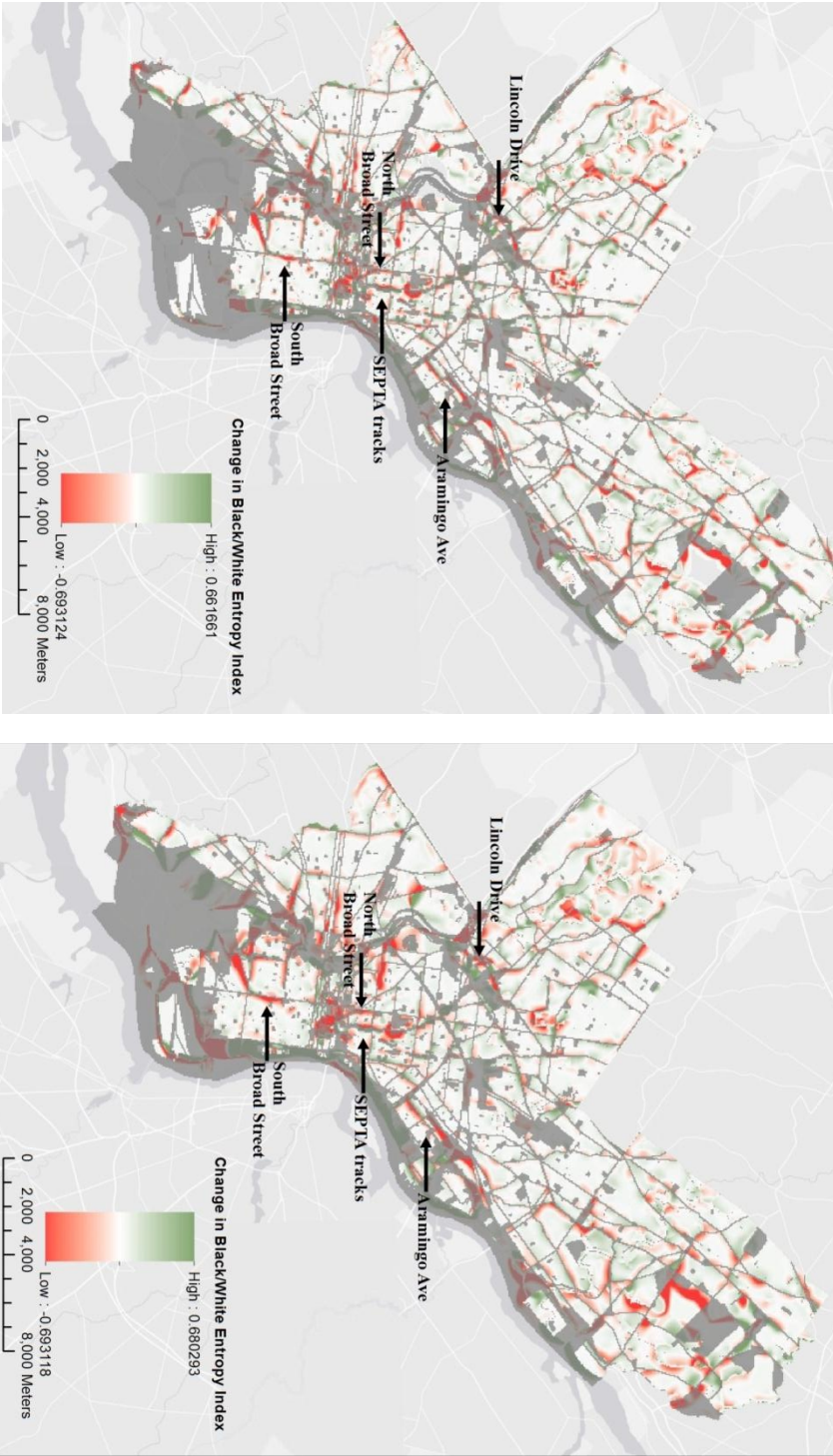
Mapping Local Patterns in 2010

As the previous chapter illustrated in case studies of West Mount Airy and University City, traditional segregation indices may hide more localized realities.

Analyzing differences in standard deviations provides preliminary evidence that barriers affect local patterns of segregation; however, mapping changes in the entropy score across simulations can illuminate those local changes in segregation that are related to the inclusion of barriers into the analysis. Figure 4.3 includes four maps of comparisons of two kernel density functions for 2010. In each map, the black-white entropy scores computed based on Euclidean kernel operations were subtracted from the black-white entropy scores computed with barriers included at 1000x friction. Areas colored red have lower entropy scores once I include barriers—that is, those locations are where barriers are effectively segregating white and black areas from each other. Areas that are shaded green have higher entropy scores once I include barriers—in other words, these are the areas that are more integrated once I include barriers in the calculation.

Imagine three neighborhoods next to each other: one that is 100% black; another is 50% black and 50% white; and a third that is also 100% black but with two barriers that separate all three neighborhoods. In this case, the areas outside of those barriers would stay 100% black after incorporating the barriers into the analysis. However, all parts of the neighborhood between those barriers would appear more mixed because the completely segregated neighborhoods now would not be a substantial part of the spatial entropy score for that integrated area. That is, the outside context of the integrated neighborhood, because it is “protected” by barriers, would not overwhelm the identification and measurement of that neighborhood. Thus, in a calculation of the difference between a Euclidean based spatial entropy score and a non-Euclidean spatial entropy score, there would be a decrease in entropy (i.e: higher segregation) in the two

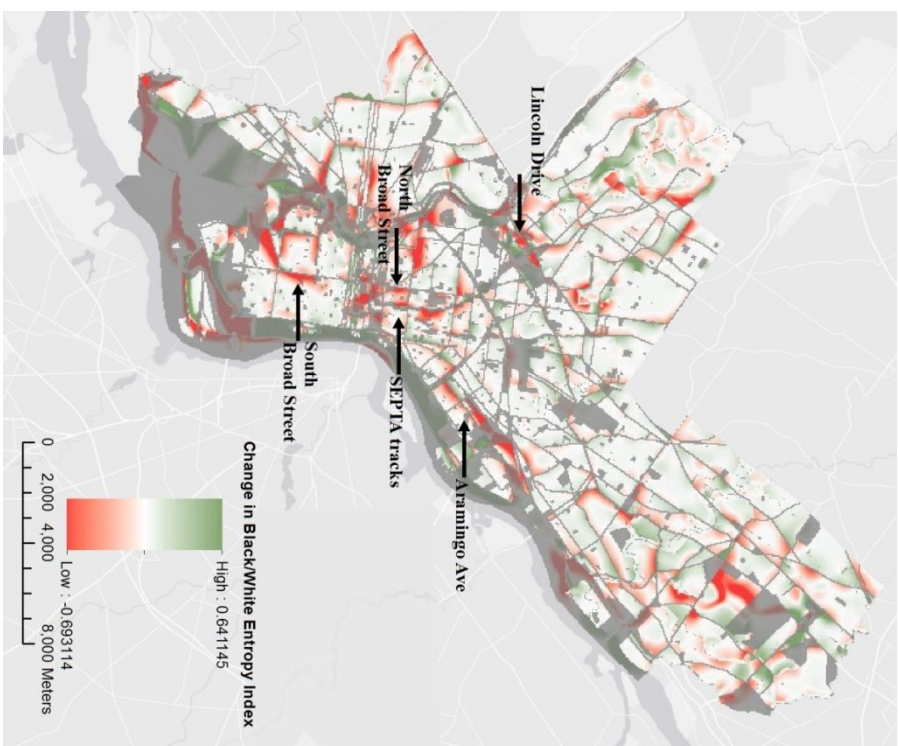
Figure 4.3. Difference of Black White Entropy Score based on Inclusion of Physical Barriers in 2010



500 Meter Kernel Density Radius

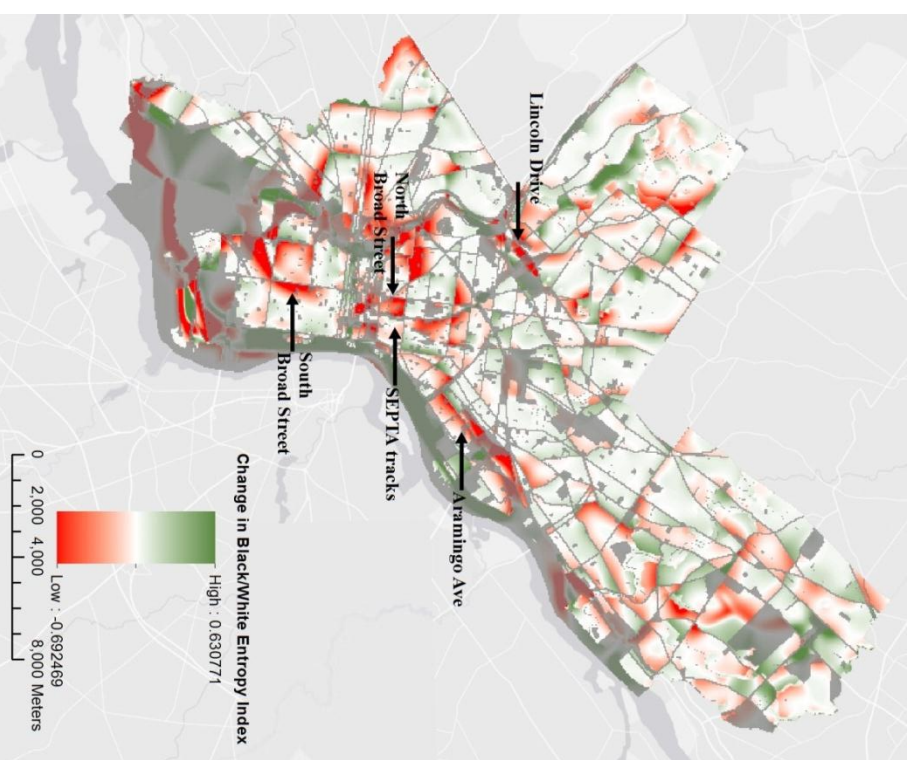
1000 Meter Kernel Density Radius

Barriers are shaded dark gray



500 Meter Kernel Density Radius

Barriers are shaded dark gray



completely segregated neighborhoods and an increase in entropy (i.e. lower segregation) in the middle, integrated neighborhood. On the maps in Figure 4.3, one side of both barriers would have would be colored red and the other side would be colored green.

In general, all four maps show the same basic patterns of change. In addition, the larger the neighborhood radius, the greater and farther-reaching the effect of incorporating barriers on the spatial pattern of residential segregation in Philadelphia. This is unsurprising; the larger a neighborhood radius, the more locations that have a barrier in their kernel *and* the more locations that cross a barrier near the center of their kernel. The closer a barrier is to the center of a kernel, the more dramatic the friction's effect on the egocentric neighborhood's residential population.

There are a number of areas on the map in which the pattern described earlier of a barrier promoting both segregation and integration on each side separately exists. Looking at the final map in the figure of the 4000-meter kernel estimates, the pattern most dramatically emerges on the central-eastern part of the city. That is where Aramingo Avenue and Frankford Creek divide predominantly white working-class Port Richmond from predominantly black and Hispanic working-class Kensington. However, in the maps of the 500- or the 1000-meter kernel estimates, that pattern does not emerge near Aramingo Avenue. Instead, making Aramingo Avenue a barrier mostly affects the level of integration to its west while having no visible effect to the east. The visible effect at the 4000-neighborhood radius is an artifact of two separate effects: Aramingo's segregating impact to the west and the Delaware River's effect that limits the effects of Philadelphia's suburbs. In this area, the population across the Delaware River

(Pennsauken Township) has a larger black population than the overwhelmingly white population of Port Richmond. Without barriers, the white area in between two densely populated, predominantly black areas would also appear predominantly black at the 4000-meter neighborhood definition. This is an example in which using too large an area to define a neighborhood can lead to inaccurate measures of local patterns of segregation, and may explain the large effects of barriers on the citywide multigroup entropy levels. A smaller neighborhood definition, then, is preferable for three reasons. First, within an urban area, the smaller neighborhood definition is geographically more similar to the census tract and thus is more readily comparable to standard sociological measures of neighborhood effects that have relied on the census tract as a proxy (Kramer 2011). Second, because the urban environment is one in which a neighborhood is often defined by a walkable area, the larger neighborhood radii with two or four kilometer radii are unjustifiably large proxies. And third, the smaller kernels isolate the effects of individual barriers on segregation patterns and are less likely to lead to inaccurate interpretations of local patterns of segregation.

A similar pattern exists in the 4000-neighborhood radius map in the northwest where Lincoln Drive and US-1 help to isolate the disproportionately black neighborhoods of East Falls and Allegheny and from more affluent and more diverse neighborhoods such as West Mount Airy. Unlike the results related to Aramingo Avenue and Frankford Creek, these results are robust at the smaller neighborhood definitions. That is, even in the 500- and 1000-meter radius maps, the expected pattern of more entropy (integration) to one side of a barrier and less entropy (segregation) on the other side is clearly visible.

Broad Street, the main north-south corridor for the city, shows an interesting pattern as well. In the south and central parts of Broad Street, there is often a substantial segregating effect. In the south, Broad Street acts as the boundary between the quickly gentrifying parts of South Philly to the east and the overwhelmingly black neighborhood of Point Breeze to the west that is not gentrifying or seeing substantial in-migration (except by Asian immigrants not shown in these maps). Just north of center city, Broad Street similarly acts as a boundary between the gentrifying areas of Spring Garden/Francisville and the ungentrified area known as Poplar, an area also isolated from gentrifying Northern Liberties to its east by SEPTA railroad tracks. The main distinction is that the gentrification just north of center city is happening predominantly to the west instead of to the east of Broad Street.

In addition, the previous chapter's other case study—University City—is largely protected by major roads and railroads and has a lower entropy score once non-Euclidean kernel density analysis is applied. Its edges, however, where gentrification is ongoing appear more integrated as they are not only bounded away from University City's majority white and Asian population but also from the predominantly black population further west and south of the expanding University City neighborhood.

Local Patterns of Multigroup Segregation

Incorporating barriers suggests a more integrated Philadelphia when calculating a multigroup entropy index. As the previous section shows, barriers—even without

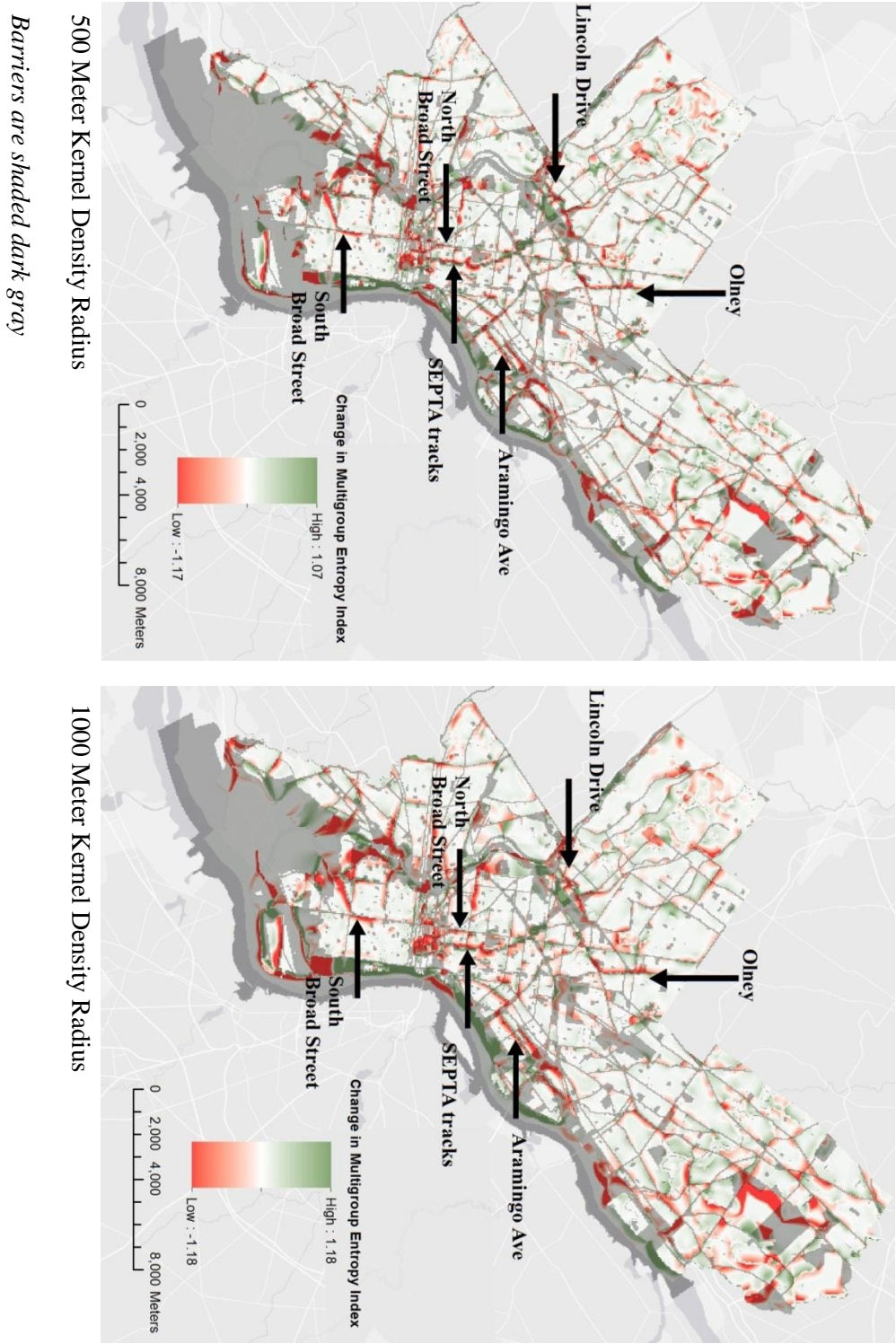
affecting citywide indexes—can exert significant influence on understandings of local patterns of black- white segregation. It remains to be seen whether and how barriers influence local patterns of multigroup segregation. The citywide entropy index results presented in Table 4.4 suggest that there should be substantial local effects on segregation patterns, but this remains to be tested.

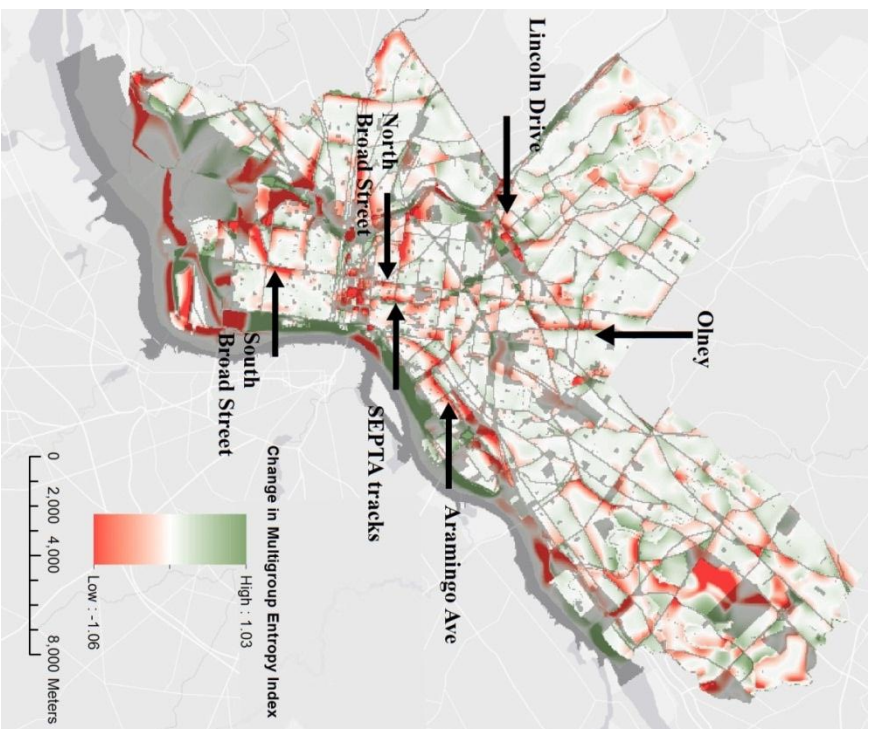
Figure 4.4 is based on the same four map analysis presented in the previous section, except that it now compares Euclidean and non-Euclidean entropy scores for the multigroup entropy scores instead of the black-white entropy scores. I focus here on the two maps for the 500-meter and 1000-meter neighborhood radii as the earlier section outlined the problems associated with interpreting local patterns of segregation using too large a neighborhood radius to construct the map.

In general, the story does not change substantially—the same barriers have largely the same effects in both sets of maps. The areas where borders had the most significant effects on black-white segregation continue to have large effects when Asians and Hispanics are included, save for some parts of West Philadelphia where including Asian and Hispanic residents near University City weakens the influence of the barriers. This is likely because the Asian residents near the University of Pennsylvania inflated the entropy score for a largely white and Asian neighborhood that is next to largely black and Asian neighborhoods.

On the other hand, including Asian and Hispanic residents introduced one new effect of barriers. In particular, the neighborhood of Olney in the north-central region of the city has seen substantial Asian immigration since 2000 and is bounded on the west by

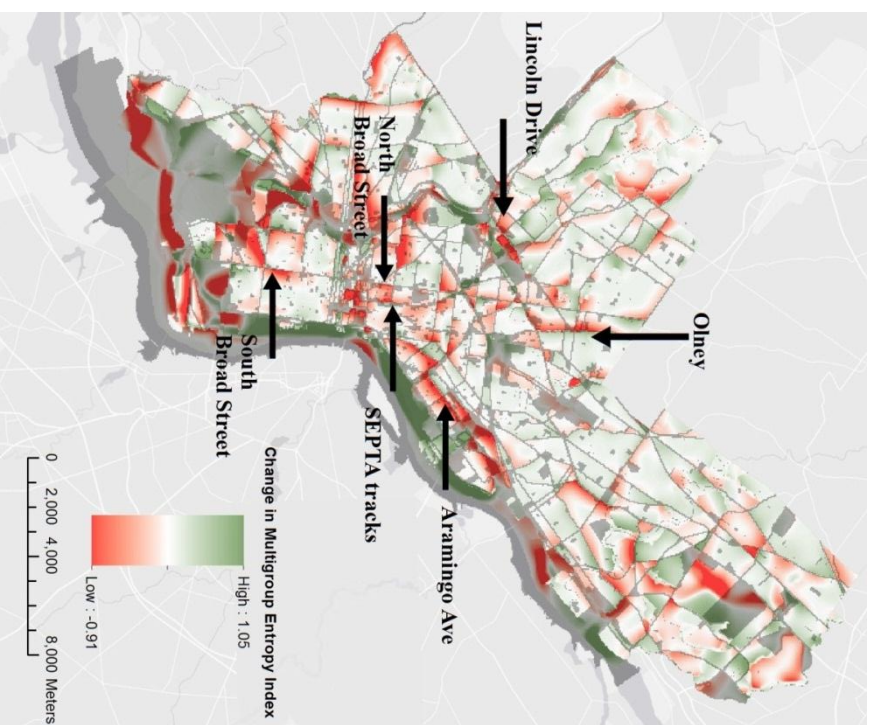
Figure 4.4. Difference of Multigroup Entropy Score based on Inclusion of Physical Barriers in 2010





500 Meter Kernel Density Radius

Barriers are shaded dark gray



1000 Meter Kernel Density Radius

railroad tracks. In the map of barrier effects for only black-white entropy, there was no impact in the northern part of the city around Olney—largely because it is overwhelmingly black outside of a substantial Asian population. Including barriers such as railroad tracks “protected” Olney’s Asian residents from the more dense, largely black populations to the west and south. Other than Olney’s re-creation as Philadelphia’s “Koreatown,” incorporating Asian and Hispanic residents does not alter the substantial and varied impact of incorporating barriers into maps of Philadelphia’s racial composition. Barriers that divided white and black populations also divided the multigroup entropy scores⁹. Similarly, other than Olney, those barriers that were not

⁹ The question remains: why is the entropy index so strongly affected by barriers? This may be an unfortunate consequence of the non-linearity of using a logarithmic function in calculating the entropy score before weighting the score by its population. Imagine that there are 100 people split equally across two areas. One is 50/50 Black and White while the other is 100% Black in a city that is 50% black and 50% white. Without a barrier, the kernel smoothing would make the two areas equal: both would be 75% black and 25% white. With the barrier in a kernel function, those two areas stay that way, but with some small amount of leakage, creating a small area with about 10% white on the segregated side and another small area that is 40% white on the integrated. In terms of dissimilarity, the barrier would work as expected, increasing the measured segregation. However, the entropy score for that area with 10% white would be .325 (instead of .1 as it would be in a linear formula, or the 0 that it had been when it was 100% black), making it appear substantially more integrated than the dissimilarity index would. At the same time, the 40% white area would have an entropy score of .67, compared to an entropy score of .69 for an even 50/50 split. That unevenness of the impact of a 10% (or any change) in the observed diversity of a given location makes the entropy score particularly susceptible to dramatic shifts due to the inclusion of barriers.

associated with boundaries between racial groups continued to have little impact on the measured level of segregation in the city.

Conclusion

Social scientists' concerns over properly measuring and identifying the neighborhood size and shape for studying the amount of and effects of residential segregation in the city have rarely been tested. Some have attempted to test the impact of measurement error by comparing different census areal units (Hipp 2007), while others have used Euclidean kernel density analysis that does not take into account the discontinuous nature of social and racial space (for discussion of the nature of racial space see, for example Neely and Samura 2011; Lee et al. 2008; Reardon et al. 2009; Lipsitz 2007; Tickamyer 2000). The first section of this chapter introduced non-Euclidean kernel density analysis, a method that allows researchers to set friction values to better simulate and approximate the discontinuous nature of social environments. As an example of those discontinuities, I incorporated barriers to interactions across spaces—major roads, rivers, railroad tracks and non-residential city blocks—into the computation of Philadelphia's entropy index in 1990, 2000, and 2010.

Overall, the inclusion of barriers had little impact on the measured level of evenness for black/white segregation. Philadelphia is hypersegregated, whether one uses census tracts, Euclidean kernels, or non-Euclidean kernels as the proxy for

Sociologists should identify a better multigroup evenness index that does not have the same flaws that are uncovered by using non-continuous kernel weightings.

neighborhoods. Barriers are not necessary for identifying the extremely high level of segregation between black and white residents in the city. There are likely two reasons for this. First, as a mathematical function, introducing discontinuity to the analysis can only heighten the measured segregation between two groups. As such, there may have been a ceiling effect—Philadelphia’s population is so segregated that even poor proxies for neighborhoods (e.g. census tracts) adequately capture that reality. Future research should compare the impact of barriers on black-white segregation in different cities. It is possible that cities with smaller black populations or with a longer tradition of non-white immigration may have segregation patterns that are more directly related to spatial barriers.

However, while barriers had little impact on observed black-white segregation, they did have an important impact on the “segregation profile,” a concept introduced by Lee and colleagues (2008) when they also introduced the use of kernel density analysis to segregation. Lee and colleagues argue that the difference between micro-segregation (the segregation identified at the 500 or 1000 meter neighborhood radius) and macro-segregation (the level of segregation at the 2000 or 4000 meter neighborhood radius) offers researchers insight into how close or far two separate racial groups live. They argue that this scale of segregation is a distinct dimension of racial segregation that warrants comparison across cities, though they note that much of this affect of scale might be due to differences in local geography (their example is of hills impacting cities such as Pittsburgh or San Francisco). However, the results from Philadelphia—a city without many hills—indicate that what they call “macro-segregation” may, in fact,

simply be an artifact of mismeasurement: once barriers are introduced to the analysis, there is no meaningful difference between the micro-segregation and the macro-segregation between black and white residents.

Second, and more theoretically, the long history of black-white segregation in Philadelphia may not need the use of identifiable barriers to delineate black and white sections of the city. Local banks that redlined neighborhoods did not necessarily need to use major streets, and that legacy can persist. Further, research on stigmatized neighborhoods (Krysan, Farley, and Couper 2008) shows that a neighborhood identified as predominantly black is stigmatized as dirty and disorganized more readily than one identified as white. It is possible that because such racial stigmatization is easily created, it does not need readily identifiable boundaries. Being on the wrong side of the tracks, in other words, may not require visible tracks to separate white and black neighborhoods in space. Again, this may not be true in other cities with smaller black populations or with newer black populations in which that local knowledge of white or black neighborhood spaces is less entrenched.

The same is not true when Asian and Hispanic residents are added to the analysis. Once they are included in a multigroup measure of entropy, the impact of incorporating boundaries grows dramatically and in an unexpected direction. In short, barriers make the city appear *more integrated* once Asian and Hispanic residents are a substantial part of the city's population. This is likely the result of two factors. First, ethnic enclaves of new and arriving immigrants are likely to need identifiable spaces to develop—such as a commercial strip on a major road like Washington Avenue in South Philadelphia—a

central location from which the ethnic enclave can expand. In that case, the enclave will be strongly affected by the incorporation of the barrier, and this, in turn, maximizes the impact of a relatively small population on measures of segregation. Second, one of the main problems of a multigroup index of entropy is that it treats all forms of segregation equally: black and Hispanic residents living in a neighborhood that is 50% black and 50% Hispanic are still likely to be in a poorly serviced neighborhood (Peterson and Krivo 2010), but that will have the same impact on the multigroup entropy index as a 50% black, 50% white neighborhood—or a 50% Asian and 50% white neighborhood. Ahistorically, all racial identities deserve equal recognition in creating multiracial neighborhoods and spaces. However, the sociological impact of segregation has clear racial winners and losers; white neighborhoods benefit from privileged racial status, while black and Hispanic neighborhoods are adversely impacted by segregation (Charles 2003; 2006; Massey and Denton 1993). As such, it is inaccurate to treat such groups as mathematically identical in the statistical analysis.

As found in the previous chapter, purely statistical analyses of spatial patterns of racial segregation can oversimplify the complex realities of social spaces. In this case, while the dissimilarity and entropy indices provided evidence that incorporating boundaries had little overall effect on reported levels of black/white segregation, incorporating barriers did have noticeable impacts on white-Asian segregation, as well as on black-Asian segregation. However, the slightly inflated standard deviation of the entropy score after inclusion of barriers indicate that the local patterns of segregation do, in fact, change. The change in entropy scores illustrates a significant pattern of border

effects. While not all, or even most, barriers lie at the nexus between two racially distinct neighborhoods, a substantial number of barriers alter the local level of segregation. For example, Aramingo Avenue and Frankford Creek combine to isolate Port Richmond's white population from the largely black and Hispanic population of Harrowgate and Feltonville to the north. Similarly, SEPTA railroad tracks and major highways separate the gentrified Manayunk and gentrifying East Falls from the disproportionately black and poor Allegheny West and Strawberry Mansion.

Including Asian and Hispanic residents in this case generally did not change the story of local patterns of residential segregation and barriers. However, there were some indications that while these groups are more integrated with whites than black residents, signs suggest that they are also impacted by barriers. For example, the Korean immigrants to Olney in North Philadelphia are residentially segregated by the elevated railroad tracks that divide Olney from East Germantown and Ogontz. Olney (to its north) has benefitted from the influx of immigrants, while a largely black community to the west has not seen much development.

These findings highlight the importance of re-orienting the social science literature on residential segregation to study the local patterns of segregation as opposed to national or even metropolitan-region scale analyses. The analysis above shows that barriers substantially impact the observed levels of segregation near them: railroad tracks isolate some of the poorest black neighborhoods in Philadelphia while Aramingo Avenue, for example, is a clear divide between a black and Latino neighborhood and its white counterpart to the West. Barriers have their impacts at the margins of these macro-scale

measures; barriers only impact the scores for those residents who actually live near barriers. The bulk of the population, however, does not live close to a major road or railroad track or river. As such, barriers may help define the edges of racially separated neighborhoods, but they do not define the totality of residential segregation.

In terms of policy, this is a critical rejoinder to social science and policy makers to reconsider the lessons of *American Apartheid*. Massey and Denton's statistical analyses were at the macro-scale, but their argument was far more micro-focused: racial residential segregation, for the individual resident, concentrates poverty in specific neighborhoods. It is those local inequalities—that poverty within Philadelphia is concentrated in black neighborhoods like Strawberry Mansion and do not spread to the whiter neighborhood of Fairmount to the south—that made segregation a structural cause of inequality. Relieving that concentration by providing spatial escape valves across barriers may help mitigate the causal impact of segregation. Isolating those barriers that have substantial local impacts on segregation can help policy makers focus efforts to redevelop those barriers (as opposed to barriers that are not related to residential segregation) into locales of cross-racial interaction and potentially sites for redevelopment as integrated communities (Anderson 2011).

Most sociologists can breathe easier, but must also alter its basic understanding of how to measure and analyze segregation. The good news is that traditional measures of segregation are not significantly biased by their inability to incorporate barriers to residential segregation: Philadelphia's two largest groups—blacks and whites--appear equally segregated whether or not such barriers are included. However, a cautionary note

is worth including: the incorporation of barriers has dramatic effects on measures of multigroup indicators of segregation, and highlights the variations in residential segregation across a city's geography. Newer immigrants are isolating and integrating themselves into the city in patterns that are significantly structured by the geography of the city. In other words, white-black segregation is so entrenched into the cultural, political, and structural aspects of the city that it does not rely on barriers. Immigrants, on the other hand, are not deeply entrenched in Philadelphia and thus have used highly visible markers such as highways or railroad tracks as physical support for building immigrant enclaves over the last 20 years. Future research should test whether or not this same distinction between black and white segregation and new immigrant group segregation exists in other cities, particularly those with longer histories of immigration (such as San Francisco or New York) or longer histories of including a sizable Hispanic population, like Miami or San Antonio.

While the overall analysis of Philadelphia as a hypersegregated whole does not undergo substantial change when barriers are included in the analysis, the local patterns that create hypersegregation change substantially in response to the inclusion of barriers. Barriers matter for local opportunities for residential integration in individual neighborhoods. While some major barriers promote racial segregation, other barriers lie between two neighborhoods with the same racial demographics, thus having no effect on measures of racial segregation. Other barriers may not be accurate any longer (as racial turnover may have extended beyond traditional barriers over time) or may actually protect an integrated neighborhood from neighboring areas with largely segregated

populations. Nonetheless, while it remains to be seen why some barriers are associated with racial segregation and some are not, it is clear that barriers are often important components of the racial geography of Philadelphia and warrant greater study within the sociology of racial inequality and segregation. The next chapter presents the first example of a sociology of barriers and neighborhood racial boundaries.

Chapter 5:

Are Racial Boundaries Consistent?

A Temporal-Spatial Examination of Racial Bounding in Philadelphia

One of the worst oversights in the sociological study of racial residential segregation has been the boundary of segregated areas—that is, how and why specific locations and spaces act on, and are acted upon by?, borders between different racial groups. To date, while sociologists have extensively measured and analyzed levels of segregation, they have not located that segregation to specific spaces within a city or region. The bulk of sociological work on residential segregation either aggregates up to the whole city (Philadelphia is hypersegregated), to regions within a city (North Philadelphia is a highly segregated black area within the city), or to specific neighborhoods (West Mount Airy is internally segregated). The previous chapter began to explore more specific locations and highlighted the reality that the neighborhood, defined as a census tract or via local agents, can appear to be both integrated overall and segregated internally. Further, the case study of West Mount Airy showed that the spatial pattern of segregation is related to the physical space, in this case the location of major roads and railroad tracks in the neighborhood.

Historically, the finding that railroad tracks and major roads bounded racial groups is unsurprising. Major highways have isolated communities in many cities, such as I-95 in the South Bronx, the Loop in Chicago, and I-91 in Boston. City planner Robert Moses is infamous for designing and constructing highways that isolated and decimated

the black and Puerto Rican South Bronx in New York City from the rest of the city. More recently in that same metropolitan area, efforts to desegregate the highly segregate and affluent suburbs of Westchester were lambasted by HUD officials and journalists for locating affordable housing required by a court settlement in an isolated block in affluent Larchmont, directly across the border from the working class and highly diverse city of New Rochelle. To add spatial insult to injury, the housing was also located behind a strip mall, tucked in a small space between railroad tracks and I-95. Similar geographic boundaries isolated the other desegregated housing throughout Westchester, including eighteen houses ostensibly in the suburb of Rye but not accessible by pedestrians or cars from Rye's town center because they are located on the opposite side of I-95 and I-287. While technically in Rye's jurisdiction, one has to enter the majority Latino Port Chester in order to re-emerge on the other side of 287 in Rye (for more details on Westchester's desegregation efforts, see Denvir 2011).

Barriers are not necessarily permanent, either for social reasons or because of policy actions. For example, Boston's North End had largely stagnated economically due to the construction of I-91 which visually and physically divided the community from the rest of Boston's metro area. For decades, that problem was compounded by political inaction or the construction of the "Big Dig" to change I-91 from an elevated highway to an underground tunnel, primarily constructed to reconnect the North End to the rest of Boston. While the building of the Big Dig is seen as an example of government ineptitude and incompetence, its completion in the 2000s coincided with and was largely responsible for a dramatic infusion of capital into the North End as property values

improved there at twice the rate of the citywide increase(Gelinas 2007). The Big Dig exemplifies both the potential of barriers to have strong impacts on social norms and how changing the use or access of a space can have similarly large impacts. The Big Dig's success also proves that barriers are not inherently consistent over time. While the Big Dig is an extreme example and involves the removal of a physical barrier, it nonetheless proves that the social demarcation of a space as undesirable or inaccessible (in this case with regard to economic segregation and undervaluation) can change. Similarly, Grannis' introduction to *From the Ground Up* (2009) shows that smaller interventions such as changed traffic patterns and improved signage can also change the social dynamics in and around major roads. These large and small shifts in the role of physical barriers in the social order are valuable rejoinders to sociologists who have long treated the neighborhood as relatively static. Neighborhood shapes and racial boundaries change over time and that change should be considered more frequently and in a more dynamic method than traditional sociological methods provide (Bader 2010).

Socially, having identifiable markers of neighborhood boundaries can help a “symbolic community” cohere and be maintained (Hunter 1982). Building from a Bourdeiuian perspective, Lamont's work (1992; 2000) has shown how people from different social classes find moral and symbolic value in their class status; individuals justify their social class by making negative moral judgments about those with objectively “better” or “worse” social class status. Similarly, the cultural explanations for racial inequality often operate on the same principle; racial inequality is not structural, but rather it is because blacks and Latinos have not assimilated enough to achieve the

“American Dream.” With regards to racial segregation, the evidence makes clear that racial in-group preferences are not at fault for segregations perpetuation, yet many common-sense, laissez-faire attitudes about racial segregation continue to rely on that faulty explanation (Friedman 2011; Bobo 2000; Charles 2003; Charles 2006; Thernstrom and Thernstrom 1997; Clark 1991).

At the same time, being able to identify a neighborhood as predominantly black or Latino makes individuals judge its desirability more harshly (Krysan and Farley 2002; Krysan, Farley and Couper 2008). That effect may be enhanced for neighborhoods with physical barriers. Easily identifiable boundaries mean that the neighborhood is easily defined as well. Creating an easily definable physical space is a useful step before imbuing a space with social and moral valuations. Barriers make it possible to easily and quickly identify “good” or “bad” areas, areas where some are “insiders” or “outsiders”¹. Further, a physical barrier can also impede interaction (as I-91 did before the Big Dig) and allow for myth-making about people from “the other side of the tracks.” While the cliché claims that ignorance is bliss, in the case of racial segregation, ignorance is bliss only in the predominantly white neighborhoods.

It is also possible that barriers can have strong impacts on residential patterns without being multi-lane highways or large, multi-billion dollar construction projects. In the previous chapter, I identified some roads that appeared to be barriers in 2010,

¹ A parallel logic exists in how cities are divided into different “gang turfs” defined by their barriers and many gangs, in fact, have been named after major roads or barriers that they claim as part of their turf.

including Aramingo Avenue, a four lane road that serves as a stark divider between a multiracial black and Latino neighborhood to its west and a white neighborhood to the East. On the other hand, Broad Street is a larger (often six lanes) road that is the major north-south running road in Philadelphia. However, unlike Aramingo Avenue, Broad Street often does not divide racial groups: in most parts of Philadelphia, Broad Street runs between two areas that have similar racial demographics, and only occasionally in South Philly and a part of lower North Philadelphia does Broad Street divide racial groups into separate neighborhoods. Though Boston's Big Dig illustrates the potential economic impact of removing or renovating physical barriers, it remains to be seen if barriers that demarcate residential segregation boundaries are equally identifiable or removable. This chapter begins to explore that question by studying where racial boundaries in Philadelphia coexist at the site of physical barriers and whether or not those racial boundaries are consistent over time. If they are, identifying those barriers that also serve as boundaries and exploring why certain barriers are or are not also racial boundaries may provide significant opportunities for policy to more actively and efficiently desegregate cities.

Methods

Quantifying Border Effects

When they introduced kernel density analysis to sociology, Reardon and colleagues (2008) privileged the role of space in calculating their entropy index and not

in reassigning the population of an area. This presentation had two benefits for their work. First, it allowed them to cite previous methodological work on how a spatial entropy index would enhance studies of segregation, especially as compared to other, more common measures of evenness such as dissimilarity (Reardon and O'Sullivan 2004). In addition, it was a far more intuitive presentation of the role of kernel density analysis on statistics about segregation: the kernel density is a corrective for measurement errors that have been a common refrain in sociology. That is, in introducing spatial analysis, their presentation was as similar to traditional quantitative sociological methods as they could make it. As such, it may have been more easily accepted and understood by sociologists than if it had been presented as a radical departure from traditional metrics.

Unfortunately, that presentation undersells the potential for kernel density analysis to revolutionize the sociological study of residential segregation. The kernel density portion of the analysis of segregation that was introduced by Reardon and colleagues (2008) and the basis of the previous chapter is the first step in a two-step method. First, the population of the city is spread, or smoothed, across the entire region (the kernel density analysis). Only after that smoothing is completed is the entropy index then calculated. Thus, it is not only possible but extremely simple to stop after the kernel density smoothing is performed and not produce an entropy index but instead pose and then answer different, novel research questions about that population and the impact of space on racial residential segregation.

For this chapter, I answer one of those novel research questions: where are racial boundaries stable or unstable? The process to do so is remarkably simple. First, after running the kernel density smoothing operation, calculate the percentage of the population of each raster cell that is the racial group is of interest, such as black or white. Next, imagine that these percentages are a third dimension on the map, as though the topography of Philadelphia is defined by the percentage black, and not the height of its hills or valleys. The slope of those hills is the rate of change in the percentage black at that point. In this extended metaphor, sharp barriers between black and non-black neighborhoods would be cliffs with sharp slopes, while areas where the two neighborhoods slowly merge into each other would be a long, slow decline. By comparing these slopes or rates of change at different locations, I can identify which specific barriers are related to racial boundaries as well.

As others have noted, however, measuring segregation at only one time may lead to inaccurate conclusions about the level of segregation at a given time or about the rate of change. For example, Point Breeze is beginning to experience racial turnover from being an almost exclusively black neighborhood to now including some white gentrifiers who have been moving further and further south of the central city in search of cheaper housing. That gentrification has been underway for nearly a decade, practically block by block. As such, during the 2010 census, Washington Avenue, a major thoroughfare, appears to be a substantial racial boundary. The areas north of Washington are between 55 and 70% white; the areas south of Washington are between 10 and 15% white. Thus, the slope at Washington Avenue would be very high, particularly if we assign it high

friction when performing the kernel density smoothing operation. However, considering the current battles over redevelopment and zoning in Point Breeze discussed in more depth in the introductory chapter, it is quite likely that the numbers below Washington Avenue have already undergone substantial change. This anecdote should provide evidence that cross-sectional data on racial boundaries may misidentify areas just beginning to undergo racial turnover as having steep boundaries. On the other hand, if a specific location has a steep slope over multiple decennial censuses, then that provides stronger evidence that that specific geography is a racial boundary. Therefore, this chapter studies racial boundaries only briefly in a cross-sectional manner before focusing on a longitudinal analysis of racial boundaries.

Every grid cell in a raster map has 8 surrounding neighbors. The slope for a given cell is measured by calculating two rates of change, one that is the rate of change in the x-direction and one in the y direction. For example, imagine the following set of 9 hypothetical cells:

A	B	C
D	E	F
G	H	I

The rate of change for cell E is calculated as $((C+2F+I)-(A+2D+G))/(8*\text{cell size})$. The y-direction rate of change is similarly defined as: $((G+2H+I)-(A+2B+C))/(8*\text{cell size})$. Using the Pythagorean theorem, these values can then be combined into a single slope

value that is the square root of the sum of the squares of the two rates of change. The slopes can then either be reported as is or converted into degrees ($^{\circ}$) by multiplying the value described above by its arctangent* $180/\pi$. As degrees, the slope can be interpreted as the angle of the leg of a right triangle. For the sake of clarity, this chapter reports all slopes as degrees².

Results

Are Barriers Actually Different?

Before analyzing specific locations within Philadelphia, it is worth determining whether or not, on average, different barriers do correspond with different rates of residential racial demographic changes. If the average barrier does not have a higher than

² Traditionally, slopes are measures of physical change the unit of measurement for the x, y, and z planes are all traditional units of distance (e.g. meters, miles, and feet). Standard slopes, then, are measured with the same unit of measurement for all three planes. However, in this application of slope, the z plane is instead a measure of population composition and cannot be converted into a unit of distance. In this case, the z variable originally ranged from 0 (no people of a given race in a cell) to 1 (a cell in which the population is entirely people of the race of interest). In an analysis where the z variable's range of values cannot be converted to a traditional unit of distance, the researcher's definition of that range impacts the observed slope—the larger the range created, the steeper the slope. As such, it is more useful to compare slopes within an analysis to each other (where the range is consistent) than to compare slopes to a predetermined cutoff point (as the range of values used to calculate the slope can have a direct impact on whether or not slopes reach that cutoff).

expected slope compared to the average slope of the entire city, that would be strong evidence that barriers do not impact residential segregation in a meaningful way. Table 5.1 reports the average slope in the percentage black at different types of spaces from maps in which there are no friction values assigned to any barriers. Accordingly these are the most conservative estimates of the difference between the slopes of barrier and non-barrier areas in Philadelphia. The table also reports the slopes at two different *a priori* neighborhood definitions, the census tract boundary and the NIS neighborhood boundary. Finally, the table also disaggregates the barriers and focuses on two types of barriers: transportation based barriers (all major roads and railroads) and nonresidential land use³.

The second column in Table 5.1 reports the average slope across every 50m x 50m cell within Philadelphia's political borders. Overall, the results indicate that slopes are very small, never averaging over 3° per cell. At their highest average in 1990 (2.69° per 50 meter cell), it would hypothetically take roughly 1100 meters to travel from a neighborhood that is 100% black to one that is 100% non-black. Remember that one's smaller the slope. At the largest neighborhood definition, 4000 meters, the slope drops to 1.15. Using the same hypothetical set up, at the largest neighborhood definition, it would take roughly 2500 meters to travel from a 100% white to a 100% black neighborhood.

³ These disaggregations do not include rivers and other waterways such as creeks. This is partially because the large majority of the water cells *are* part of the Delaware and Schuylkill Rivers *and are* barriers that are also located at the edge of Philadelphia. Thus, river cells *may be* proxies for the political boundaries of opting to either live inside or outside of the city proper. Roads and railroad tracks were aggregated together because many roads and railways are either adjacent to each other (such as the SEPTA tracks that run next to I-95 in parts of Philadelphia) or directly on top of each other (such as the elevated subway tracks on Frankford Avenue and Market Street).

However, that only occurs if the slope is continually in the same direction—slopes, because they are calculated by summing squares—do not indicate direction. Without incorporating the direction of the change, the average reports a faster change in the hypotheticals above than in reality. A black neighborhood may border a more racially mixed neighborhood which may then share a border with another black neighborhood. If that is the case -- and it is in parts of Philadelphia -- then the hypothetical above is a misleadingly optimistic representation of slopes. Nonetheless, it is useful to visualize what the difference in slopes implies about the relative rates of change over different spaces.

Overall, the slope does not change significantly over time, especially between 2000 and 2010. Between 1990 and 2000, the average slope decreases across the city at the smaller, more realistic neighborhood definitions. The average slope when I set the neighborhood's radius at 500 meters dropped from 2.69 in 1990 to 2.18 in 2000 and stayed constant between 2000 and 2010. At the 1000 meter radius, the slope dropped from 2.06 in 1990 to 1.83 and continued to fall slightly down to 1.78 in 2010. The larger "neighborhood" in that hypothetical is only 500 meters in radius. Thus, it would take traveling across more than two whole neighborhoods to experience that transition. In addition and as one would expect, the larger the definition of a neighborhood's radius, the neighborhood definitions are almost identical across all three decennial censuses, only changing by .12 over the entire 30 year period under study at most.

The third and fourth columns in the table look at the two *a priori* definitions of

Table 5.1. Black/Non-Black Slopes

	Philadelphia	Census Track Boundaries	NIS Neighborhood boundaries	All Barriers combined	Non- residential spaces	Roads and Railways
1990						
500 meters	2.69 (4.985)	3.09 (4.526)	3.15 (4.927)	2.81 (5.672)	2.58 (5.500)	3.55 (5.615)
1000 meters	2.06 (3.380)	2.29 (3.151)	2.35 (3.323)	2.18 (3.782)	1.95 (3.552)	2.58 (3.667)
2000 meters	1.55 (2.292)	1.72 (2.235)	1.72 (2.292)	1.66 (2.578)	1.55 (2.406)	1.89 (2.578)
4000 meters	1.15 (1.489)	1.20 (1.375)	1.26 (1.432)	1.26 (1.662)	1.20 (1.604)	1.38 (1.662)
<i>N</i>	<i>146941</i>	<i>19323</i>	<i>9904</i>	<i>68237</i>	<i>38470</i>	<i>22259</i>
2000						
500 meters	2.18 (4.068)	2.23 (3.552) ^{ns}	2.41 (3.782)	2.64 (5.271)	2.52 (5.099)	2.58 (4.526)
1000 meters	1.83 (3.037)	1.83 (2.693) ^{ns}	2.01 (2.922)	2.23 (3.896)	2.12 (3.724)	2.18 (3.610)
2000 meters	1.49 (2.235)	1.49 (1.948) ^{ns}	1.66 (2.235)	1.83 (2.922)	1.78 (2.980)	1.72 (2.437)
4000 meters	1.20 (1.604)	1.20 (1.375) ^{ns}	1.32 (1.500)	1.43 (2.063)	1.38 (2.120)	1.38 (1.719)
<i>N</i>	<i>146941</i>	<i>20000</i>	<i>9904</i>	<i>57223</i>	<i>26542</i>	<i>22259</i>
2010						
500 meters	2.18 (3.896)	2.12 (2.807)*	2.41 (3.839)	2.75 (5.100)	2.75 (5.042)	2.64 (4.297)
1000 meters	1.78 (2.751)	1.67 (2.063)	1.95 (2.636)	2.23 (3.495)	2.23 (3.552)	2.12 (3.094)
2000 meters	1.43 (1.891)	1.38 (1.546)	1.60 (2.005)	1.83 (2.406)	1.83 (2.521)	1.66 (2.063)
4000 meters	1.15 (1.318)	1.09 (1.146)	1.26 (1.318)	1.43 (1.662)	1.43 (1.719)	1.26 (1.432)
<i>N</i>	<i>146941</i>	<i>19929</i>	<i>9904</i>	<i>54876</i>	<i>24105</i>	<i>22259</i>

*Note: All values are statistically significantly different from Philadelphia average at the .001 level except those with ns (non-significant) or * ($p < .05$) after*

local neighborhoods. The first are the census tract boundaries that split the city into tracts, between 350 and 365 in number depending on the census in question. Because the boundaries shift slightly across decennial censuses in order to better reflect the changing populations on the ground, the total number of raster cells that are identified as “census tract boundaries” is not constant but undergoes only small changes each decade. Second, the NIS neighborhoods are larger than census tracts and split the city into only 69 total “neighborhoods” (one of which is a large park with few residents) that largely correspond with census tract boundaries. The NIS neighborhoods were identified by local agencies in the 1990s and have not been updated since. As such, the raster cells identified as “NIS neighborhood boundaries” did not change across the time period under study.

The results in the third column indicate that census tract boundaries do an increasingly poor job of identifying where there are particularly sharp breaks in racial demographics. In 1990, the average census tract had a steeper slope than the whole city’s average at every neighborhood definition. At the 500 meter radius, the census tracts boundaries’ slopes drop from an average over 3 to 2.23 and then down to 2.12 by 2010. In fact, the results in 2000 for all four neighborhood sizes (500, 1000, 2000, and 4000 meters) are not significantly different than we would expect from a random sample of cells taken from across Philadelphia. The average slope of 2.12, while significantly different from the average of all cells in Philadelphia, is different *in the wrong direction*; census tract boundaries actually had below average slopes. Like in 2000, that result is repeated at every sized kernel density: the census tracts have slopes below that of the

average grid cell throughout Philadelphia. These results further call into question the adequacy of relying on the census tract as an appropriate proxy of neighborhoods.

It may be, however, that no other *a priori* neighborhood boundary or barriers are better than the census. The fourth column tests that possibility by measuring the average slope of NIS neighborhood boundaries. Because there are fewer NIS neighborhoods, there are also fewer grid cells that fall on an NIS boundary (9,904 cells as opposed to between 19,000 and 20,000 for the census tracts). In 1990, the NIS values and the census tract values were almost identical, within 0.1 at all neighborhood radii. The similarity is unsurprising given that the NIS neighborhoods were created based, in large part, on results from the 1990 census. By 2000, on the other hand, the NIS neighborhood boundaries have consistently higher slopes than both the census tract boundaries and the average Philadelphia grid cell. At all neighborhood radii in 2000, the NIS neighborhood boundary is between 0.12 and 0.20° higher than the values at the census tract. In 2010, that gap only grows larger to nearly 0.30 at the 500 and 1000 meter radii. Looking longitudinally, both boundary types' average slopes drop across all the decennial censuses. This comparison of NIS neighborhood boundaries and census tract boundaries presents another problem for traditional analyses of segregation that rely on the census tract. The fact that the boundaries do not correspond with substantially steeper slopes and that other *a priori* neighborhood definitions correspond more accurately with steeper slopes highlights the inadequacy of the assumption that the census tract is an acceptable proxy for the neighborhood with regards to racial segregation.

The final three columns in Table 5.1 show the average slope at the barriers that were given friction values in chapter 4. Column 5 is the average for all of the barriers identified for chapter 4—nonresidential blocks, waterways, major roads, and railroad tracks. Across all three decennial censuses and all four kernel density radii, barriers have steeper slopes compared to the whole of Philadelphia. In 1990, that difference is statistically significant but relatively small—consistently between 0.10 and 0.20° compared to the city average. By 2000, the city’s average slope had decreased quickly but the barrier’s average slope did not. The city’s average slope at 500 meters dropped from 2.69 in 1990 to 2.18 in 2000 and stabilized through 2010. The barrier’s slope, on the other hand, only dropped 0.17° from 2.81 to 2.64 and actually grew at the larger radii. In 2010, the average barrier’s slope at 500 meters also grew back towards its high in 1990 to 2.75 , while it stayed identical at the other three, larger neighborhood radii. Overall, these results, coupled with the findings for census tract and NIS neighborhood boundaries, provide strong evidence that the boundaries of residential segregation are better captured by a barrier-based approach compared to traditional approaches that use administratively defined proxies for neighborhoods.

Columns 6 and 7 disaggregate two of the three types of barriers identified as part of this project. The major roads and railways did not change across decennial censuses while the areas identified as nonresidential blocks shrank from a high of 68,237 grid cells (almost 46% of the city’s space) to a low of 54,876 grid cells (roughly 37% of the city’s entire geography). As Grengs (2007) shows, treating nonresidential spaces as though they were residential can introduce a bias towards lowered reported segregation in a city. The

results from table 5.1 confirm that finding, as the nonresidential spaces consistently have above average slopes. However, compared to other barriers (either the average of all types of barriers or specifically roads and railways), nonresidential spaces have relatively lower slopes. Roads and railroads are relatively strong identifiers of locations with steeper racial change in 1990 when the average road or railroad cell is almost a full° higher than the average city cell at the 500 meter neighborhood radius. As the radius gets larger, that association persists but grows weaker: at 1000 meters, the roads and railroads are over a half a degree higher; at 2000, they are roughly one third a° higher; and by the largest neighborhood radius definition, they are just under a quarter° steeper on average. In 2000 and 2010, the results are more muted, but roads and railroads nonetheless do correspond to higher average slopes. Further, those results are not only true when comparing roads and railroads to the average grid cell, but also when comparing them to NIS neighborhood boundaries or to census tract boundaries.

It is possible that the slopes reported in table 5.1 and their gradual improvement over time is due to the growing Hispanic and Asian populations and not due to a decrease in black/white segregation. Table 5.2 tests that possibility by excluding the Hispanic and Asian populations from the sample. In general, limiting the analysis to black and white residents alone led to steeper slopes in Philadelphia across parts of all three decennial censuses. In 1990, that finding was at its weakest, only persisting at the 500 and 1000 meter neighborhood radii. The relative weakness of that finding should be unsurprising as Hispanic and Asian residents accounted for less than ten percent of the population in 1990. In fact, that they had any effect is notable. By 2000, after a decade of in-migration

by Asians and Hispanics and out-migration by blacks and whites, the impact grew more consistent across the larger radii but still was a relatively small effect, only increasing the slope by 0.17 at the smallest radius and 0.05 at the largest two. It is only in 2010 that the Asian and Hispanic populations grew to be nearly 20% of the city's total population, and removing them from the analysis has a much more noticeable effect on the reported slope. At the 500 meter and 1000 meter neighborhood definitions, focusing on black-white slopes as opposed to black-non-black slopes increased the average slope by nearly 0.30° and nearly 0.20° . At the larger and somewhat unwieldy 2000 and 4000 meter neighborhood radii, the effect persisted, though weakened to just over 0.10° at the largest neighborhood definition.

The results for *a priori* neighborhood boundaries and barriers are more extreme once I exclude Asian and Hispanic residents. The census tract boundaries and NIS boundaries generally see little change when compared to the results for those same boundaries in Table 5.1. The only census tract slope that changed by more than 0.15° was the average slope in 2000 at the 500 meter neighborhood radius. At the same time, the difference between the census tract's average slope and that of the city average was statistically non-significant in 2000. The NIS neighborhood boundaries saw more of an effect in 2000 and 2010, increasing by roughly 0.20° at both the 500 and 1000 meter neighborhood radii. These increases appear even smaller in comparison to the results for the barriers reported in the final three columns of the table. While all barriers combined and the roads and railroads did not experience substantial change, nonresidential spaces

Table 5.2. Black/White Slopes

	Philadelphia	Census Track Boundaries	NIS Neighborhood boundaries	All Barriers combined	Non- residential spaces	Roads and Railways
1990						
500 meters	2.81 (5.48)	3.15 (4.92)	3.21 (5.31)	2.92 (6.33)	3.46 (6.05)	3.55 (5.88)
1000 meters	2.12 (3.78)	2.35 (3.55)	2.41 (3.78)	2.23 (4.35)	2.06 (4.06)*	2.69 (4.34)
2000 meters	1.55 (2.35)	1.66 (2.18)	1.72 (2.35)	1.72 (2.75)	1.67 (2.69)	1.89 (2.46)
4000 meters	1.20 (1.60)	1.21 (1.37) ^{ns}	1.32 (1.49)	1.32 (1.82)	1.20 (1.66) ^{ns}	1.37 (1.60)
<i>N</i>	<i>146941</i>	<i>19323</i>	<i>9904</i>	<i>68237</i>	<i>38470</i>	<i>22259</i>
2000						
500 meters	2.35 (4.80)	2.41 (4.06) ^{ns}	2.58 (4.35)	2.98 (6.39)	2.81 (6.22)	2.75 (5.14)
1000 meters	1.95 (3.55)	1.95 (3.26) ^{ns}	2.23 (2.83)	2.52 (4.86)	2.40 (4.74)	2.29 (3.95)
2000 meters	1.55 (2.46)	1.55 (2.18) ^{ns}	1.78 (2.52)	2.06 (3.38)	1.95 (3.32)	1.78 (2.75)
4000 meters	1.25 (1.78)	1.26 (1.49) ^{ns}	1.37 (1.72)	1.60 (2.29)	1.49 (2.35)	1.43 (1.83)
<i>N</i>	<i>146941</i>	<i>20000</i>	<i>9904</i>	<i>57223</i>	<i>26542</i>	<i>22259</i>
2010						
500 meters	2.46 (5.14)	2.23 (3.21)	2.63 (4.40)	3.26 (6.96)	3.43 (7.80)	2.81 (5.20)
1000 meters	1.95 (3.55)	1.76 (2.25)	2.18 (3.26)	2.70 (4.92)	2.86 (5.65)	2.18 (3.54)
2000 meters	1.60 (2.41)	1.43 (1.78)	1.72 (2.12)	2.18 (3.26)	2.29 (3.66)	1.78 (2.46)
4000 meters	1.26 (1.66)	1.20 (1.32)	1.32 (1.37)	1.60 (2.06)	1.66 (2.12)	1.43 (1.78)
<i>N</i>	<i>146941</i>	<i>19929</i>	<i>9904</i>	<i>54876</i>	<i>24105</i>	<i>22259</i>

*Note: All values are statistically significantly different from Philadelphia average at the .001 level except those with ns (non-significant) or * ($p < .05$) after*

were much more impactful at the 500 meter radius in 1990, jumping almost a full degree once the analysis focuses on black-white instead of black-non-black results. In 2000, the results are more consistent across barrier types and neighborhood radii, if less steep. For all three barrier columns, the slope grew roughly 0.30° steeper when compared to the earlier results at the 500 and 1000 meter radii. The larger radii saw smaller increases, but still over 0.10° , except for roads and railroads at the 4000 meter radius. Results in 2010 follow the same pattern, but are even greater—an average increase of 0.50° compared to the results in Table 5.1, except for roads and railroads. It appears that black-white segregation is more strongly associated with nonresidential use (or disuse) of space compared to black-non-black segregation, while major roads and railroads work to separate black neighborhoods from any non-black community, regardless of the ethnic and racial background of that other community.

That barriers are associated with different forms of segregation for black residents in Philadelphia begs the question about whether or not we see the same effect for white residents as well. Table 5.3, when combined with the results for Table 5.2, offers some preliminary answers. For black residents, slopes were generally higher for black-white segregation than for black-non-black segregation. For white residents, however, the results are reversed: the slopes in Table 5.3 for white-non-white segregation are either as high as or higher than the results for black-white segregation. That is, the slopes of segregation in Philadelphia indicate that the primary divide is white-non-white. Slopes in Philadelphia as reported in column 2 are slightly higher in 1990 and 2000 in Table 5.3, though those increases are do not persist to the largest neighborhood definition and by

2010 the slopes are effectively identical to those for white-black segregation. Columns 3 and 4 in Table 5.3 are almost identical to those in Table 5.2, illustrating that census tract and NIS neighborhood boundaries are not separating white and black residents any more than they separate whites from Asians and Latinos. In addition, it appears that the barriers are more important for white residential neighborhoods than for blacks: barriers in 1990 and 2000 have much higher slopes in Table 5.3 than either Table 5.1 or Table 5.2. In 1990, slopes for all barriers are at least 0.80° higher than for black-white segregation (and a full degree higher than black-non-black segregation) at the 500 meter radius. In 2000, that difference has decreased, but is still a full half point higher. In 2010, however, barriers have the same slopes for both white-non-white segregation and black-white segregation. Splitting barriers into their component types helps elucidate further patterns. Nonresidential spaces are strongly associated with higher slopes in 1990 and 2000 across all four neighborhood radii, while roads and railroads gave nearly equal slopes across all four radii when comparing the white-non-white and black-white segregation slopes. By 2010, Asians and Hispanics had grown to be a larger proportion of the population and whites became a numerical minority for the first time in Philadelphia, the slopes at barriers for white-non-white and black-white segregation were equal. Interestingly, that is not true at the largest neighborhood radii (4000), where white-non-white segregation is now higher than black-white segregation. Roads and railroads now have a much smaller impact on white-non-white segregation than on black-white segregation, likely due to the growing Asian population and its relatively low level of segregation from white residents in Philadelphia as reported in Chapter Four.

Table 5.3. White/Non-White Slopes

	Philadelphia	Census Track Boundaries	NIS Neighborhood boundaries	All Barriers combined	Non- residential spaces	Roads and Railways
1990						
500 meters	3.21 (5.99)	3.15 (4.92) ^{ns}	3.55 (5.48)	3.78 (7.58)	3.89 (8.03)	3.66 (5.82)
1000 meters	2.29 (3.66)	2.35 (3.55)*	2.41 (3.26)	2.58 (4.52)	2.52 (4.46)	2.69 (3.72)
2000 meters	1.66 (2.41)	1.66 (2.18) ^{ns}	1.78 (2.23)	1.95 (2.98)	1.95 (3.03)	1.95 (2.41)
4000 meters	1.26 (1.55)	1.20 (1.37)	1.26 (1.49) ^{ns}	1.38 (1.83)	1.37 (1.83)	1.43 (1.66)
<i>N</i>	<i>146941</i>	<i>19323</i>	<i>9904</i>	<i>68237</i>	<i>38470</i>	<i>22259</i>
2000						
500 meters	2.58 (4.74)	2.35 (3.55)	2.52 (3.78) ^{ns}	3.49 (6.84)	3.49 (6.84)	2.81 (4.69)
1000 meters	2.06 (3.43)	1.95 (2.75)	2.06 (2.92) ^{ns}	2.81 (4.74)	2.92 (5.03)	2.41 (3.78)
2000 meters	1.72 (2.52)	1.60 (1.95)	1.72 (2.18) ^{ns}	2.29 (3.43)	2.41 (3.66)	1.89 (2.69)
4000 meters	1.32 (1.66)	1.26 (1.37)	1.37 (1.55)*	1.72 (2.23)	1.66 (2.23)	1.43 (1.72)
<i>N</i>	<i>146941</i>	<i>20000</i>	<i>9904</i>	<i>57223</i>	<i>26542</i>	<i>22259</i>
2010						
500 meters	2.40 (4.23)	2.23 (3.21)	2.46 (3.43) ^{ns}	3.26 (6.28)	3.32 (6.28)	2.57 (3.95)
1000 meters	2.00 (3.21)	1.78 (2.23)	2.06 (2.63) ^{ns}	2.69 (4.52)	2.92 (5.09)	2.12 (2.98)
2000 meters	1.65 (2.29)	1.32 (1.72)	1.66 (1.89) ^{ns}	2.23 (3.21)	2.41 (4.23)	1.72 (1.23)
4000 meters	1.32 (1.66)	1.20 (1.26)	1.32 (1.37) ^{ns}	1.78 (2.18)	2.00 (3.21)	1.43 (1.72)
<i>N</i>	<i>146941</i>	<i>19929</i>	<i>9904</i>	<i>54876</i>	<i>24105</i>	<i>22259</i>

*Note: All values are statistically significantly different from Philadelphia average at the .001 level except those with ns (non-significant) or * ($p < .05$) after*

Tables 5.4 and 5.5 repeat the above analyses for Asian-non-Asian and Hispanic-non-Hispanic segregation in 2000 and 2010. The previous census is excluded from these tables because neither group was large enough in 1990 to warrant analysis. Average slopes for both groups were much smaller than those for blacks and whites because large swaths of Philadelphia had no Asian or Hispanic residents. In such areas, the slope is set at zero. This is another reason why it is more valuable to study the differences within analyses instead of comparing across multiple different groups: it is not accurate to say that whites are more bounded by barriers than Asians or Hispanics. The *a priori* neighborhoods are particularly poor at locating where there is racial change over space with regard to Asians and Hispanics; for both groups, the census tract boundary has a lower average slope than the average Philadelphia grid cell at the 1000 and 2000 meter radii (though that difference is non-significant for Asians at the 1000 meter slope). The NIS neighborhood boundaries fare even worse for both groups in 2010. For Asians and Hispanics, it is almost 0.10 lower than the average for all of Philadelphia at the 500 meter radius before and is consistently smaller at the other radii.

In fact, while the slopes for both tables never come close to even reaching 1 degree in steepness, there is some evidence that barriers are more strongly associated with Asian and Hispanic segregation than for whites or blacks. In 2010 at the 500 meter neighborhood radius, for example, nonresidential spaces are over .2 degrees steeper than the average Philadelphia grid cell with regard to change in the percentage of the population that is Asians. While this is a small change in terms of absolute numbers, it is

Table 5.4 Asian/Non Asian Slopes

	Philadelphia	Census Track Boundaries	NIS Neighborhood boundaries	All Barriers combined	Non- residential spaces	Roads and Railways
2000						
500 meters	.352 (.705)	.370 (.713)	.162 (.277)	.380 (.841)	.395 (.890)	.437 (.925)
1000 meters	.267 (.528)	.279 (.541)*	.289 (.546)	.279 (.638)	.281 (.653)	.329 (.693)
2000 meters	.202 (.376)	.212 (.395)	.217 (.373)	.214 (.446)	.214 (.452)	.253 (.493)
4000 meters	.154 (.239)	.160 (.248)	.164 (.240)	.162 (.277)	.162 (.275)	.190 (.311)
<i>N</i>	146941	20000	9904	57223	26542	22259
2010						
500 meters	.472 (.962)	.493 (.884)*	.227 (.292)	.577 (1.29)	.705 (1.61)	.564 (1.05)
1000 meters	.368 (.664)	.365 (.626) ^{ns}	.377 (.666) ^{ns}	.439 (.840)	.525 (.992)	.419 (.718)
2000 meters	.276 (.419)	.266 (.389)	.278 (.397) ^{ns}	.316 (.490)	.361 (.560)	.308 (.450)
4000 meters	.200 (.256)	.197 (.241) ^{ns}	.203 (.244) ^{ns}	.227 (.292)	.255 (.313)	.230 (.293)
<i>N</i>	146941	19929	9904	54876	24105	22259

*Note: All values are statistically significantly different from Philadelphia average at the .001 level except those with ns (non-significant) or * ($p < .05$) after*

a nearly 50% increase when compared to the baseline of 0.472. The same is true for Hispanic residents with almost identical numbers (0.704 and 0.476 as compared to 0.705 and 0.472 for Asians). As with white residential slopes, roads and railroads have smaller slopes than nonresidential areas.

Overall, the tables demonstrate that *a priori* neighborhood boundaries do a poor job of identifying the locations that divide races, and that they get progressive worse with each decennial census. That finding is not due to census tract or NIS neighborhoods

Table 5.5 Hispanic/Non-Hispanic Slopes

	Philadelphia	Census Tract Boundaries	NIS Neighborhood boundaries	All Barriers combined	Non- residential spaces	Roads and Railways
2000						
500 meters	.352 (.785)	.365 (.756)*	.315 (.682)	.443 (1.05)	.443 (.906)	.411 (.772)
1000 meters	.269 (.619)	.280 (.594)*	.277 (.635) ^{ns}	.328 (.791)	.303 (.648)	.305 (.617)
2000 meters	.218 (.498)	.230 (.510)	.230 (.540)*	.266 (.613)	.227 (.467)*	.242 (.493)
4000 meters	.178 (.395)	.189 (.410)	.162 (.277)	.211 (.473)	.179 (.351) ^{ns}	.197 (.374)
<i>N</i>	146941	20000	9904	57223	26542	22259
2010						
500 meters	.476 (1.28)	.457 (1.85) ^{ns}	.382 (.704)	.704 (1.94)	.721 (1.74)	.573 (1.33)
1000 meters	.375 (.985)	.347 (.661)	.310 (.578)	.547 (1.41)	.623 (1.67)	.428 (.957)
2000 meters	.304 (.728)	.279 (.538)	.250 (.476)	.430 (1.01)	.505 (1.27)	.326 (.651)
4000 meters	.241 (.516)	.223 (.443)	.227 (.292)*	.319 (.661)	.345 (.769)	.265 (.533)
<i>N</i>	146941	19929	9904	54876	24105	22259

Note: All values are statistically significantly different from Philadelphia

being overly specific: there were *fewer* grid cells identified as falling on a census tract boundary or NIS boundary than either of the barriers disaggregated in the tables above that consistently have higher average slopes than the census tract and NIS results. These results are confirmed across multiple censuses and multiple different neighborhood radii, even incorporating the non-Euclidean analysis introduced in Chapter Four. Doing so would only increase the inaccuracies highlighted here. Having shown the value of focusing on barriers in lieu of administrative boundaries, the next section of the chapter

studies which barriers are particularly strong and consistently strong dividers of racial groups from each other.

Barriers Over Time

In the original formulation of the racial invasion/succession model, Park (1925) asserts that racial succession spreads in a manner of invasion, spreading almost like a liquid across a surface, crossing from one “natural area” to another, mostly spreading through geographic proximity. Even in these original formulations, invasion/succession was not a purely geographic process—“natural areas” divided the city into different regions that would experience turnover at different paces. Some “natural areas” were advantaged either via racial, socioeconomic, or geographic advantages to be able to be near a growing black or poor population but not experience invasion due to those advantages (Zorbaugh’s *The Gold Coast and the Slums* is particularly relevant here). Later formulations illustrated some of the mechanisms through which racial invasion and succession can be often constrained by institutional forces, such as outright racial segregation by lending institutions (Massey and Denton 1993), or density zoning (Massey, Rothwell, and Domina 2009; Rothwell and Massey 2009). In both cases, barriers may play key roles in organizing racial segregation. In a weaker model of barrier effects, barriers that act as racial boundaries may slow the invasion/succession until the unevenness between the two sides is so great that it eventually leads to spillover. In this case, a barrier inhibits and constrains racial turnover but does not completely remove the

possibility of turnover. Alternatively, in a strong model of barrier effects, barriers that are racial boundaries would be absolute blockers, and the proportion black on one side of the barrier would have no impact on whether or not the proportion black on the other side of the barrier changes over time. Because neighborhoods have more than one barrier and because both the weak and strong models may occur at different barriers, it is difficult to identify which of the two is occurring in a given space. It may be that a given barrier is a strong boundary between two neighborhoods with different racial demographics, but that one neighborhood has a weaker boundary elsewhere. That neighborhood may experience racial turnover through invasion via the weak barrier. Regardless of where that invasion occurs, the end result would be that the strong barrier would eventually appear to have weakened after the invasion spreads throughout the neighborhood. Therefore, while this chapter cannot adjudicate between strong and weak barrier effects, it can still identify which barriers are consistently associated with racial boundaries across two decades. Once identified, those relatively strong and consistent racial boundaries can be examined in more detail to determine whether or not there are similarities within that group that may identify why and how certain barrier are or are not more likely to be racial boundaries.

One caveat to this analysis is that the location barriers change over time. Fortunately, Philadelphia's major roads and railroad tracks were all built before this study's time period. However, the amount of space that had no residential use changed both in size and location over the three time periods. While the large majority of such spaces were consistently nonresidential across all three decennial censuses, there were

noticeable changes around the borders of some areas as commercial corridors expanded or shrank, as vacant blocks were redeveloped, or as some blocks lost all of their residents. So as not to bias results by including nonresidential spaces that were residential at one time period but not another, I only include nonresidential areas in this part of the analysis if they were consistently nonresidential during all of the time periods under study. For example, if an area was nonresidential in 1990 but not in 2000 or 2010 (or vice versa), it is excluded from the analysis of the consistency of racial boundaries, even though it was treated as nonresidential in the kernel density smoothing technique in 1990.

In addition, the friction values of the barriers may have an impact on whether or not they appear consistent over time. If the population size on one side of a barrier increased between 1990 and 2000, without setting a high friction value at the barrier, it would appear that the barrier has grown weaker after kernel density smoothing, as the one side's impact on the slope would be larger than in 1990. Therefore, to avoid any bias that may come from population size changes and not via racial change, I use results from the kernel density smoothing in which barriers have friction values of 1000. This test allows the best comparison of barriers to each other compared to using one of the simulations with lower friction values at barriers. Whether or not the friction value is most accurate to real life experiences of segregation is still unknown—but this will best identify differences in barriers' impact, assuming some barriers do impact segregation patterns. If a given barrier does not impact racial segregation, then the populations on both sides of the barrier should be roughly equal in racial demographics, even if I set the barrier's friction at a high level as the two areas near the barrier would have only small

changes in racial identity before smoothing those populations. If a barrier does have an impact on racial segregation and also population density (as Massey and Rockwell argue) and I do not set a high friction level at the barrier, it may appear to have a low impact on segregation because the larger population on one side of the barrier would inaccurately cross into the other neighborhood and artificially decrease the slope at the barrier.

Tables 5.6 through 5.8 provide matrices of changes in slope across decennial censuses. Each table reports three different slopes: those for percentage white/non-whites, black/white, and black/non-black. Rows in each table represent the steepness of the slope at the original time, while columns represent the steepness of the slope at time 2. Table 5.6 compares the slopes at barriers in 1990 to 2000, and Table 5.7 compares the slopes between 2000-2010; Table 5.8 measures the changes between 1990 and 2010 for a longer term measure of barrier slopes. Slopes were divided into five categories. The large majority of the slopes are 0° , and any slope below 5° is considered gentle. Between 5° and 10° is a slightly larger slope, but one that would still take between 250 and 500 meters to change from an entirely white to an entirely non-white area—assuming all 250-500 meters had the same slope in the same direction. Slopes above 20° take under 250 meters to change entirely from white to non-white and are equivalent to at least a 30% change in the proportion white across just one grid cell. All slopes were computed using the 1000 meter neighborhood radius and set barrier friction at 1000 times greater than residential friction. I use the 1000 meter radius as the two larger neighborhood radii used in the prior chapter are larger than most neighborhoods and produced overly extreme results that

might bias results⁴. Focusing on the 1000 meter radius is thus a more conservative test of barrier slopes than the larger radii, while the 500 meter radius is more accurately equated to a sub-neighborhood area in size. The rows of each table are the slopes at the first time period under study, while the columns are the slopes at the second time period of that table. For example, the numbers in Row 1, Column 4 in Table 5.6 are the total number of barrier cells that had a slope under 5° in 1990 and had a slope above 20° in 2000. The diagonals are the cells that had a consistent slope value at both decennial censuses.

The overwhelming majority of barriers are not racial boundaries at a given time, and most have consistently gentle racial slopes across two decennial censuses. More than 50% of the black/white and black/non-black slopes were below 5° in both 1990 and 2000. Over 48% of the white/non-white slopes were similarly consistently low. This is unsurprising as previous research has shown that not only are individual neighborhoods racially segregated, but that segregation is spatially clustered—white neighborhoods are normally adjacent to other white neighborhoods, black neighborhoods to black neighborhoods, etc. (Sampson 2012; Peterson and Krivo 2010). Barriers are likely to have small slopes, then, for two reasons. First, the barrier may lie at the boundary between two neighborhoods with similar racial demographics and thus, while the barrier defines a neighborhood boundary, it does not define a racial boundary. Second, some

⁴ Philadelphia is also a somewhat oddly shaped city in that it is very narrow east to west in parts. In fact, parts of the central business district's neighborhood, if the 4000 meter radius is used for a neighborhood proxy, would have neighborhoods that be so large as to end only 500 meters away from the suburbs. That radius would encompass parts of 16 of the 69 NIS neighborhoods.

Table 5.6 Change in Slopes at Barriers, 1000 Meter Neighborhood Radius 1990-2000

White/Non-White Slope		1	2	3	4	Total
<5°	1	24266	<i>3605</i>	<i>3285</i>	<i>2722</i>	33878
5-10°	2	3950	1001	<i>828</i>	<i>635</i>	6414
10-20°	3	3440	870	1040	<i>809</i>	6159
>20°	4	2177	215	461	811	3664
Total		33833	5796	5614	4977	50220
Black/White Slope		1	2	3	4	Total
<5°	1	31530	<i>2929</i>	<i>2481</i>	<i>1617</i>	38557
5-10°	2	3294	822	<i>620</i>	<i>524</i>	5260
10-20°	3	2231	591	599	<i>508</i>	3929
>20°	4	1218	201	342	645	2406
Total		38273	4611	4042	3294	50220
Black/Non-Black Slope		1	2	3	4	Total
<5°	1	31731	<i>2795</i>	<i>2435</i>	<i>1422</i>	38383
5-10°	2	3082	908	<i>702</i>	<i>563</i>	5255
10-20°	3	2342	717	770	<i>552</i>	4381
>20°	4	915	217	361	660	2153
Total		38070	4685	4268	3197	50220

**Rows are slopes for 1990, columns are slopes for 2000. Italicized cells represent border cells (50m x 50m) where the slope increased between 1990 and 2000.*

barriers may run inside neighborhoods. For example, the SEPTA train tracks that bisect West Mount Airy are only a few blocks away from Germantown Avenue, a major arterial street. Only one of those two barriers is going to be a neighborhood boundary, and only one (but not necessarily the neighborhood boundary) will act as a racial boundary. Similarly, the Schuylkill River is bounded on both sides by major roads such as Kelly Drive, I-76, and West River Drive. While all three are barriers, only one edge will have a steep slope, as that edge is where the kernel density smoothing is first impeded by high friction.

Moving away from the barriers that have consistently low racial slopes, the slopes reported in Table 5.6 point to two unexpected trends. First, even though Philadelphia grew slightly more integrated over time, it was more likely that a barrier grew *steeper* and not gentler for all three slopes in question. This may be due to two concurrent mechanisms. Between 1990 and 2000, Philadelphia's population fell, especially its white population. It is possible that whites disproportionately left from previously integrated areas (West Mount Airy's population, for example, halved between 1990 and 2000, mostly due to the exodus of white residents), retreating as a population to more "defensible" locations behind barriers with smaller, but growing, minority populations. In other words, white residents may have moved from a fully integrated neighborhood to a far more segregated neighborhood across a barrier, but one that is less segregated than in previous decades. City-wide measures might report an overall decrease in segregation, but the barriers around that more segregated neighborhood would grow sharper as the area next to it would have shifted from integrated to segregated non-white. Second, zones

of integration (either temporarily undergoing racial turnover or a more permanent integration) may be particularly well defined spaces that then only attract residents interested in integrating as part of their mobility decisions. For example, Northern Liberties is a gentrifying neighborhood in which a majority black population has seen a white in-migration due to redevelopment. Northern Liberties, before it reached a tipping point sometime in the 2000s, was a temporarily integrated neighborhood with sharp boundaries in all directions—between it and overwhelmingly black Poplar to its west, largely black and Latino Kensington to its North, and disproportionately white Fishtown and Old City to the East and South, respectively. When it was a predominantly black neighborhood in 1990 the only barriers that would have steep racial slopes in 1990 would be those between Northern Liberties and Fishtown and Old City. Once it became highly integrated in 2000 (albeit only temporarily), all of its barriers would have high racial slopes as all of its surrounding areas continued to be predominantly monoracial.

The second unexpected trend in Table 5.6 is that amongst barriers that began the 1990s with high racial slopes, it was more common to enter the 21st century with low slopes than with high slopes. While consistency is the norm when one looks at all barriers across Philadelphia because the majority of barriers are never racial boundaries, focusing on those barriers that begin as racial boundaries (those in Rows 3 and 4) uncovers this trend. Almost two thirds of all barrier cells that had slopes above 10° had slopes below 10° by 2000 across all three racial divides in the table. Those same results are only slightly depressed if one only focuses on the cells that had racial slopes greater than 20° in 1990; between 50% and 55% of those slopes fell under 10° by 2000. While this

dissertation has shown that barriers organize racial segregation, which barriers perform that function changes with each passing decade.

A comparison of the three different racial slopes presented in Table 5.6 offers a hint as to how and why those slopes shift. Overall, the three racial slopes show similar patterns (which should not surprise as black and white residents made up over 85% of the city's population in both 1990 and 2000). However, some small differences are noticeable in the results. First, barriers were far more likely to have racial slopes when computing white/non-white slopes than the black/white or black/non-black slopes. Roughly 20% fewer barriers had gentle slopes under 5° in the white/non-white measure compared to the other two. Similarly, roughly 50% more slopes had extremely high slopes ($>20^{\circ}$) in the white/non-white measurement compared to the other two measures of racial slope, and a greater share of the slopes were consistently above 10° in both 1990 and 2000 (6.4% of slopes compared to 4.1% for the black/white and 4.6% in the black/Non-black slopes). In sum, even when white and black residents are almost the entirety of the population, barriers are more likely to be used to create defensibly segregated communities or areas for whites than to hem in black or other minority communities from expansion. From 1990 to 2000, Philadelphia's population fell and immigration had just begun to pick up, while the center city area underwent reinvestment and redevelopment to entice suburban and wealthier individuals back into the city. Between 2000 and 2010, the center city and some other areas saw strong growth (before the Great Recession wiped much of that progress away). While white and black residents continued to leave the city at a slightly slower pace than in the 1990s, immigration by

Asians and Latinos (and some Africans and Afro-Caribbeans) more than offset the loss of white and black residents, and Philadelphia's population, against expectations, grew between 2000 and 2010.

The decade between 2000 and 2010 in Table 5.7 repeats some of same patterns as Table 5.6. Before analyzing the results, it is worth noting that the total number of barrier cells falls by nearly 100 because the number of nonresidential barrier cells falls slightly, likely due to the development of more mixed-use buildings in the central city and the slight population growth during the decade. In addition, while the total number of cells changed only slightly, the location of those barriers underwent much more change. Looking at row totals compared to the column totals in Table 5.6, many more barriers were related during the 2000 census with gradual slopes for whites/non-whites in Table 5.7 than were identified as gradually sloped in 2000 in Table 6.6. These shifts were not as substantial for black/white slopes (though substantially fewer barriers were identified as having slopes above 20° in Table 5.7 than in Table 5.6), while the black/non-black slopes were more likely in Table 5.7 to have moderate slopes between 5 and 20 degrees.

Once again, the majority of barriers continue to have slopes under 5°, and the white/non-white slopes are also more likely to be higher than the other racial slopes under study. For whites as with the previous decade, barriers are more likely to become steeper than to become more gradual. However, there are some important changes within those larger patterns that indicate that racial boundaries are beginning to cohere more closely

Table 5.7 Change in Slopes at Barriers, 1000 Meter Neighborhood Radius 2000-2010

White/Non-White Slope		1	2	3	4	Total
<5°	1	27887	<i>3780</i>	<i>2543</i>	<i>1285</i>	35495
5-10°	2	3059	1415	<i>1161</i>	<i>458</i>	6093
10-20°	3	2053	945	1633	<i>744</i>	5375
>20°	4	1160	286	636	1002	3084
Total		34159	6502	5973	3489	50123
Black/White Slope		1	2	3	4	Total
<5°	1	31972	<i>3132</i>	<i>1704</i>	<i>951</i>	37759
5-10°	2	3031	1186	<i>801</i>	<i>246</i>	5264
10-20°	3	2018	640	1107	<i>547</i>	4312
>20°	4	1297	220	418	766	2701
Total		38318	5265	4030	2510	50123
Black/Non-black Slope		1	2	3	4	Total
<5°	1	31777	<i>3028</i>	<i>1797</i>	<i>659</i>	37261
5-10°	2	3101	1324	<i>985</i>	<i>267</i>	5677
10-20°	3	2174	733	1249	<i>530</i>	4686
>20°	4	1115	225	398	686	2424
Total		38167	5385	4429	2142	50123

**Rows are slopes for 2000, columns are slopes for 2010. Italicized cells represent border cells (50m x 50m) where the slope increased between 2000 and 2010.*

with barriers. First, even though the total number of barrier cells fell, over 3,000 more barriers were consistently unassociated with white/non-white boundaries and had a slope of less than 5° in both 2000 and 2010 compared to the previous decade. Overall, 64.3% of all white/non-white barriers were consistent between 2000-2010, compared to only 54% in 1990-2010. The black/white and black/non-black slopes were also more consistent in the 2000-2010 decade compared to 1990-2000 (both went from 67.7% consistent to 70% consistent). For the latter two slopes, the bulk of that increase did not come at the $<5^\circ$ level as it did for white/non-white slopes, but rather at the $5-10^\circ$ and $10-20^\circ$ level. In sum, barriers were growing more consistently associated with racial boundaries, and that consistency also means more steep slope barriers are persistent. In addition, while white/non-white barriers saw their slopes increase more frequently than decrease once again, those increases were less dramatic than in the 1990s. For white/non-white barriers, the 1990s saw over 4,000 barrier slopes grow to be above 20° by 2000. During the 2000s, just fewer than 2,500 barrier cell slopes grew above 20° by 2010. More of the slope change came as barriers less than 10° in 2000 grew moderately to $10-20^\circ$ slopes. There were only half as many slopes that grew by at least 10° in the 2000s compared to the 1990s.

Focusing on black/white and black/non-black slopes, a new narrative emerges of barriers becoming less important in organizing racial segregation. Between 2000 and 2010, 500 grid cells, representing over 7% of the total with slopes above 10° , dropped from having over 10° slopes to under 10° slopes when we focus on black/white slopes. Three possibilities emerge to explain this change. First, it is possible that blacks and whites in

Philadelphia actually grew more integrated in general. If so, we should expect an even more substantial drop in the black/non-black barriers as we know that blacks and Asians and Latinos are more integrated than blacks and whites. The second possibility is that black and white neighborhoods grew separated by buffer zones of Asian and Latino populations. In this second possibility, while black and white residents remain segregated, the slope is weakened because of the larger area between the two groups. In other words, the barriers that protected white residents in 1990 and 2000 from neighboring black residents now instead protect white residents from neighboring Asian or Latino residents while the black residents are on the other side of those Asian and Latino residents. If that is the case, black/non-black results should see even higher slopes than black/white slopes. Finally, the third possibility is that the Asian and Latino immigrants are segmentedly assimilating, where some immigrants are separated from nearby black communities by barriers (such as the Korean immigrants into Olney) while others are moving into largely black neighborhoods (such as the Southeast Asian immigrants into Point Breeze). The results for the black/non-black section of the table echo the results from the 1990s—barriers act mostly to divide whites from non-whites and not to divide blacks from Asians or Latinos. The results for black/non-black and black/white slopes are practically identical. Returning to the possibilities listed above, that similarity indicates that the third possibility is the most accurate: immigration's impact on racial boundaries is the same as the results in 1990 with regards to racial boundaries and barriers for black and white residents. Barriers have their biggest impacts

on racial segregation and racial slopes as a means of isolating and protecting white residents.

Table 5.8 looks at the changes from 1990 through 2010. In general, the story remains the same; excluding those cells that never have racial slopes above 5°, consistency is atypical. Looking at the white/non-white part of the table where consistency is the most common, only 11.4% of the other barrier cells are consistent across all of the other categories. Even splitting the slopes into only those above 10° and below 10°, only 37.8% of the barrier cells that start with high slopes continue to have a high slope in 2010.

Turning to black/non-black instead, 11.8% of the barrier cells (excluding those that are always non-boundaries) are consistent and only 35% of the barrier cells with slopes over 10° in 1990 have barrier cells above 10° in 2010. White/non-white racial boundaries once again have the largest slopes at barriers across the entire period under study compared to black/white or black/non-black boundaries. Unlike in Table 5.7, however, there are noticeable differences between black/white and black/non-black boundaries. While the total number of cells with slopes over 10° or 20° are the almost identical in both 1990 and 2000, black/non-black slopes are more likely to be consistently high slopes compared to black/white slopes which were more likely to have undergone change. For example, almost 60% of the black/white slopes that were over 20° in 1990 were under 5° in 2010. By comparison, only 45% of the black/non-black slopes over 20° in 1990 were under 5° in 2010. Those differences in consistency are likely related to the steady location of ethnic enclaves for immigrants over time compared to white residents' higher levels of residential mobility.

Table 5.8 Change in Slopes at Barriers, 1000 Meter Neighborhood Radius 1990-2010

White/Non-White Slope		1	2	3	4	Total
<5°	1	23844	<i>3747</i>	<i>3329</i>	<i>2611</i>	33531
5-10°	2	3452	856	<i>832</i>	<i>602</i>	5742
10-20°	3	2699	741	942	<i>843</i>	5225
>20°	4	1499	248	452	907	3106
Total		31494	5654	5555	4963	47666
Black/White Slope		1	2	3	4	Total
<5°	1	28319	<i>3048</i>	<i>2586</i>	<i>1740</i>	35693
5-10°	2	3395	675	<i>559</i>	<i>383</i>	5012
10-20°	3	2726	479	495	<i>475</i>	4175
>20°	4	1625	190	315	596	2726
Total		36065	4452	3955	3194	47666
Black/Non-Black Slope		1	2	3	4	Total
<5°	1	28731	<i>2841</i>	<i>2407</i>	<i>1296</i>	35275
5-10°	2	3454	797	<i>649</i>	<i>489</i>	5389
10-20°	3	2558	615	716	<i>613</i>	4502
>20°	4	1113	211	395	733	2452
Total		35856	4512	4167	3131	47666

**Rows are slopes for 1990, columns are slopes for 2010. Italicized cells represent border cells (50m x 50m) where the slope increased between 1990 and 2010.*

One way to test whether or not the differences between black/white slopes and black/non-black slopes are related to white or black isolation is to study the Asian and Hispanic slopes between 2000 and 2010. Asian residents grew from just under 5% of Philadelphia's population in 2000 to over 6.3% in 2010 while Hispanics saw somewhat faster growth—from 8.5% in 2000 to 12.3% in 2010. Thus, based purely on the difference in absolute numbers, Hispanic residents should have higher slopes on average compared to Asian residents. Table 5.9 compares the consistency of borders for Asian and Hispanic residents between 2000 and 2010. As expected, Hispanic residents experience higher racial slopes in both 2000 and 2010 compared to Asian immigrants. However, one difference is worth noting. The Asian population in 2010 was nearly the same size as the Latino population in 2000. Thus, we may expect that the Hispanic slopes in 2000 would be slightly larger than those for Asians in 2010 *if* we expect both groups to experience segregation in a similar manner. Of course, results from the previous chapter and from previous studies of racial and ethnic differences in segregation show that Hispanics experience higher levels of segregation than Asians in general (Charles 2003; 2006; Iceland 2009). The barrier values, however, do not correspond with that analysis. Barriers for Hispanics in 2000 were less likely to have slopes over 10° than Asians in 2010 and more likely to experience slopes below 5° as well. In short, even though we would expect barriers to have more of an impact on Hispanic residents than on Asians, the opposite is the case when comparing the groups at similar sizes but different decades. Turning to 2010, two trends are captured in the data. First, both groups see substantial increases in the likelihood that a barrier is associated with a higher slope. For both, the

total number of grid cells that have slopes over 10° roughly doubles (from 563 to 1,195 for Asians and from 1,081 to 1,804 for Hispanics). Hispanics also experience a sharp increase in the number of extreme slopes over 20° from 152 to 455, while Asians experience a much weaker growth in extreme slopes from 118 to only 166 cells, but see a doubling of high slopes between 10° and 20° between 2000 and 2010 from 445 to 1,030 cells.

Table 5.9 Change in Asian and Hispanic Slopes at Barriers, 1000 Meter Neighborhood Radius 2000-2010

Asian/Non-Asian		1	2	3	4	Total
<5°	1	45543	<i>1814</i>	<i>707</i>	<i>92</i>	48156
5-10°	2	835	402	<i>153</i>	<i>14</i>	1404
10-20°	3	168	127	133	<i>17</i>	445
>20°	4	27	11	37	43	118
Total		46573	2354	1030	166	50123
Hispanic/Non-Hispanic		1	2	3	4	Total
<5°	1	44181	<i>2095</i>	<i>843</i>	<i>284</i>	47403
5-10°	2	1004	472	<i>171</i>	<i>32</i>	1679
10-20°	3	386	155	290	<i>98</i>	929
>20°	4	40	27	44	41	152
Total		45611	2749	1348	455	50123

*Rows are slopes for 2000, columns are slopes for 2010. *Italicized cells represent border cells (50m x 50m) where the slope increased between 2000 and 2010.*

Hispanics and Asians, as they grow into a larger share of Philadelphia's total population, also begin to experience more of an effect of barriers on their residential neighborhoods. This is probably due to the expansion of ethnic enclaves and their growth from small minority of a single area to a substantial minority and even majority of areas of Philadelphia. However, while these immigrant enclaves are experiencing higher slopes, they are still relatively few in number and small in size. The bulk of the Asian and Hispanic immigration may explain at least part of the difference between the white/non-white and the black/non-black slopes; those immigrant destinations within the city that are near white populations are more likely to be blocked off by barriers such as major roads (Chinatown, for example, is hemmed in on all sides from the majority white center city neighborhoods to its west and south by the Convention Center and by the arterial Market Street). On the other hand, those immigrant destinations in or near black populations are more likely to not be hemmed in by barriers, such as the Southeast Asian enclave in Point Breeze and the Hispanic populations in and near Kensington (though the Korean enclave of Olney is a counter example where railroad tracks are a strong separator between the "Koreatown of Philadelphia" and a large black community).

Consistent Barriers: Locations and Possible Explanations

The analysis above showed that barriers are rarely consistent racial boundaries in Philadelphia. Racial segregation and residential patterns are constantly evolving and changing, and the impact of individual barriers changes along with those demographic

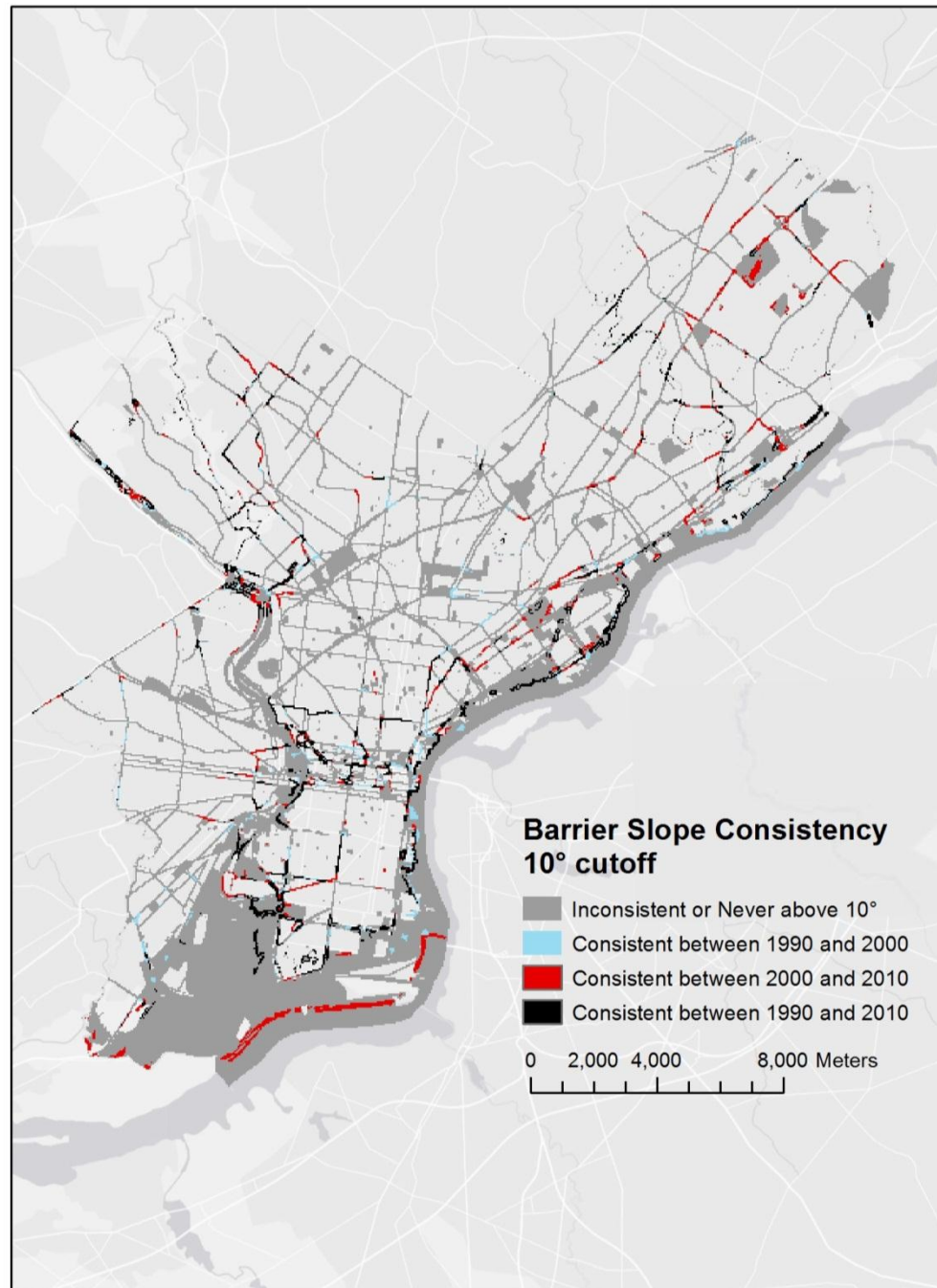
forces. In general, though, the analysis above showed that barriers are more commonly associated with white neighborhood boundaries. As Mike Davis (1992) argues, architecture and city planning most commonly has been used to isolate and protect whites and their privileged spaces and neighborhoods. Many white residents have been moving out of the city, but those that remain are using barriers more and more to isolate themselves from non-white residents. Though barriers are more likely to experience change in their racial slopes, a minority of barriers have consistently steep slopes. Identifying those barriers that are consistent racial boundaries may have implications for understanding why certain areas resist racial turnover and what may help spur desegregation efforts in those communities and neighborhoods.

Figure 5.1 is a map in which barriers that have consistently high racial slopes across at least two census periods are identified by color. Dark gray areas are barriers in which the white/non-white racial slope is either always below 10° or is only above 10° for one census period. As the results from the tables showed, the large majority of border cells are dark gray, though the map also indicates that these results are potentially biased by the area in the southwest part of Philadelphia that is taken up by large industrial areas, sports stadiums, and the Philadelphia International Airport. Nonetheless, the large majority of barrier cells are not consistently high, especially in West Philadelphia and North Philadelphia—both highly segregated black areas of the city. Barriers that are consistently high in 1990 and 2000 are colored blue, those consistently high 2000 and 2010 are red, and those that are consistently high in 1990, 2000, and 2010 are in black.

Due to the relative scarcity of consistent high slopes, it is hard to identify specific barriers of interest from a map of the entirety of Philadelphia. Some trends are apparent, though. First, relatively few barriers were consistent in 1990 and 2000 but not in 2010—only about 15% of the cells identified as consistently high were categorized as such in 1990 and 2000 but not 2010. Second, the northeastern section of Philadelphia, a traditionally white working and middle class section of the city, mostly saw its barriers become racial boundaries after 1990, as many of the barriers in that area are colored red on the map. Third, Lincoln Drive, as noted in the previous chapter, is a consistently high barrier in all three census periods.

One of the other advantages of looking at a map of all of Philadelphia is that it can identify sub-areas worth looking at in more detail. Figures 5.2, 5.3, and 5.4 do so by comparing sets of maps of the same areas. Each set has three maps: one of consistency of white/non-white slopes, another of black/white slopes, and a third of black/non-black slopes. Figure 5.2 focuses on West Mount Airy, one of the case studies used in chapter 3. West Mount Airy prides itself on being purposefully integrated since the 1960s, though chapter 3 identified some trends toward segregation. The maps here confirm the evidence from chapter Three. The areas in the northern section of the map are the main dividing lines between Chestnut Hill, a wealthy white area, and West Oak Lane, a predominantly black, middle class neighborhood. More importantly for West Mount Airy, the two black areas of West Mount Airy are isolated from the majority white area by barriers with steep slopes—in particular, Wissahickon Avenue is consistent across all three census periods while the SEPTA railroad tracks (the S shaped curve in the middle of the map) is a steep

Figure 5.1. Map of White/Non-White Racial Slopes at Barriers, 1000 meter neighborhood radius

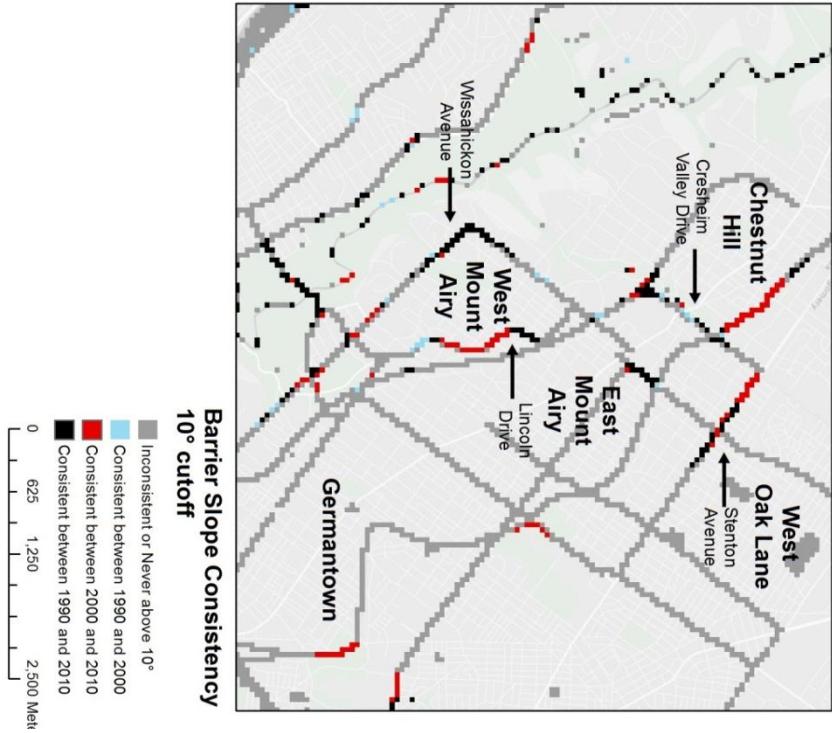


racial boundary in both 2000 and 2010, as the analysis in Chapter 3 would predict. As that part of Philadelphia has seen little Asian or Hispanic immigration, the slope's consistency is not affected by which racial groups are mapped.

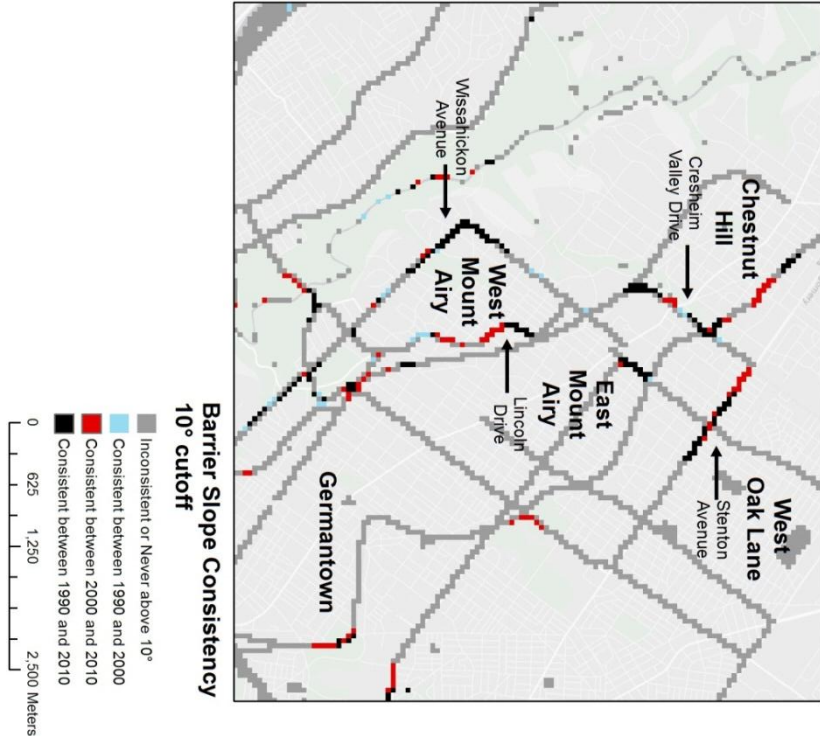
Figure 5.3 takes a closer look at the Center City neighborhoods in the upper part of the map and South Philadelphia (including Point Breeze/Newbold) toward the bottom of the map. Once again, a comparison of all three maps shows only small differences dependent on which racial slope is under study. The white/non-white and black/white slopes are particularly similar, except on the edges of the Schuylkill and Delaware Rivers, where the white/non-white slopes are steeper, likely due to the growing Hispanic population in Camden across the Delaware and the Asian population in West Philadelphia just across the Schuylkill River. Moving to the consistent barriers, the largely black Point Breeze neighborhood is bounded to the South by two separate barriers, Snyder Avenue and West Passyunk Avenue, and the southern part of 25th Street, though that last barrier does not extend far north. Broad Street is a consistently steep barrier as well for whites, who are primarily found to the East of Broad, leaving Point Breeze neglected and isolated next to the reinvigorated, traditionally Italian eastern part of South Philadelphia. In sum, from the first two maps, it appears that Point Breeze is hemmed in on three sides. The third map, which focuses on black/non-black boundaries, shows the impact of immigration. The southern part of Broad Street where Snyder and Broad met is now an inconsistent barrier as the large Asian immigration near Broad Street and the Hispanic and Asian immigration into the eastern side of South Philadelphia between Washington Avenue and Snyder Avenue have created a more multiracial area

Figure 5.2. Maps of Racial Slopes, West Mount Airy region of Northwest Philadelphia, 1000 meter neighborhood radius

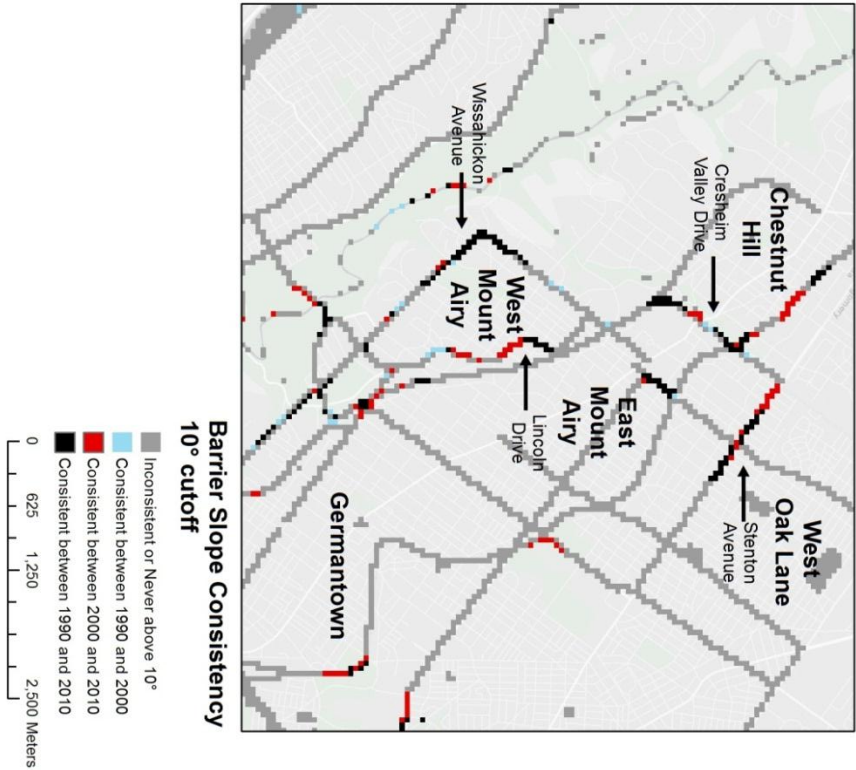
White/Non-White Slopes



Black/White Slope



Black/Non-Black



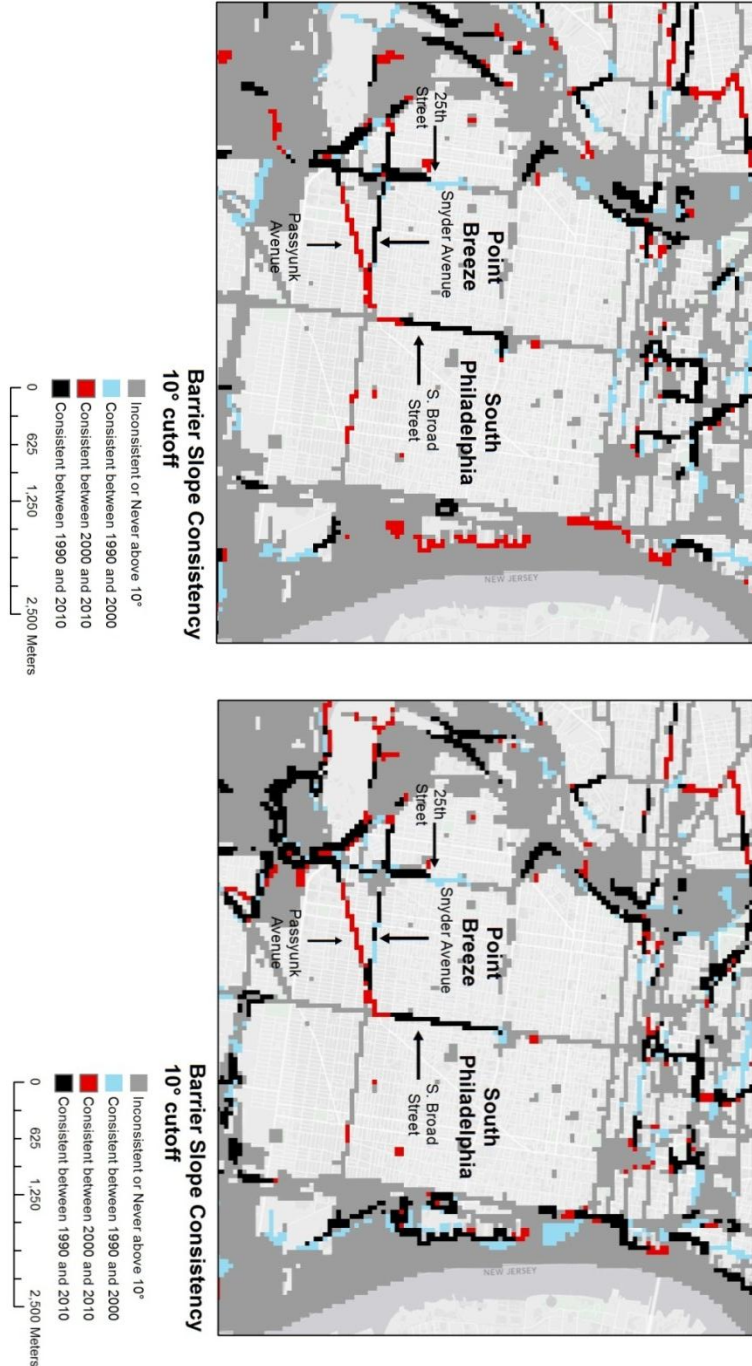
with gentler slopes. Importantly, while that immigration has relaxed black/non-black boundaries, the white/non-white barriers remained consistently strong--evidence that immigration is buffering the divide between black and white populations. However, to return to the battles over the gentrification of Point Breeze that introduced this chapter, it is clear that the lack of barriers to the north of Point Breeze helps explain why gentrification has slowly spread from the north to the south. There is no major road that separates the wealthy Rittenhouse area of Center City from the southwest part of South Philadelphia. As such, gentrification and redevelopment had a direct line to follow from Center City to the area now known as "Graduate Hospital" through to Point Breeze.

The final set of maps in Figure 5.4 looks at a third set of neighborhoods with historic identities. Port Richmond and Fishtown on the Delaware have long histories as white working class neighborhoods in Philadelphia, including large Polish and Russian immigrant communities throughout the 20th century. To their west lies West Kensington, a previously white working class community that instead experienced racial turnover in the 1950s and 1960s into a largely black and then Hispanic community. The first map shows that the white populations of Fishtown and Port Richmond are strongly isolated by major roads as boundaries, as Frankford Avenue and then Aramingo Avenue are both consistently steep. Frankford Avenue, along with the elevated subway line above North Front Street, is consistently steep from 1990 through 2010, while Aramingo Avenue is only consistently steep in 2000 and 2010, only in 1990 because the eastern parts of Kensington had not yet seen large Hispanic immigration. In addition, the area of Northern Liberties, a major hub of redevelopment and gentrification, is protected by

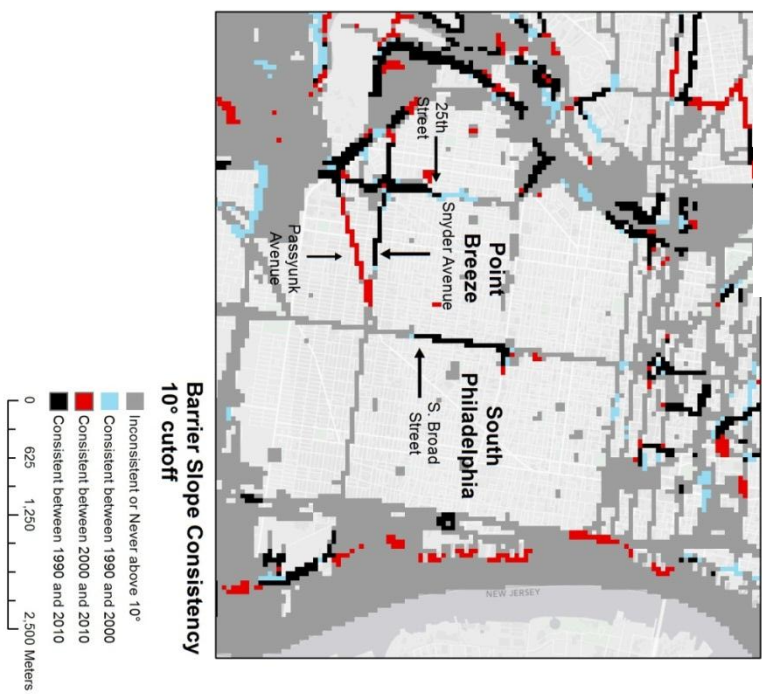
Figure 5.3. Maps of Racial Slopes, South Philadelphia and Center City, 1000 meter neighborhood radius

White/Non-White Slopes

Black/White Slope



Black/Non-Black



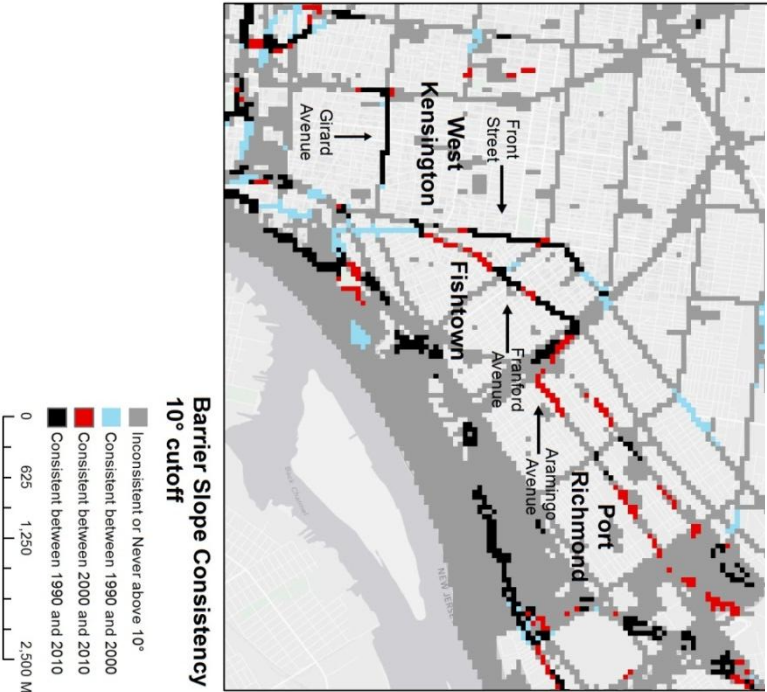
Girard Avenue from the blighted areas of South Kensington.

The second two maps show that the steep slopes for white/non-white racial change are not related to black/white divides. The second map shows that if we focus on black/white slopes, most of the consistency seen in this area disappears. There is still a divide on Front Street, and the division between North Liberties and South Kensington is consistent. In addition, a new slope is identified in the north between the largely black and Hispanic Harrowgate neighborhood and the rest of Northeast Philadelphia, a largely white area. This consistency was not identified in the white/non-white map because a growing Hispanic and Asian population has been moving into the areas north of Harrowgate—while the black population of Harrowgate has geographically expanded to the north.

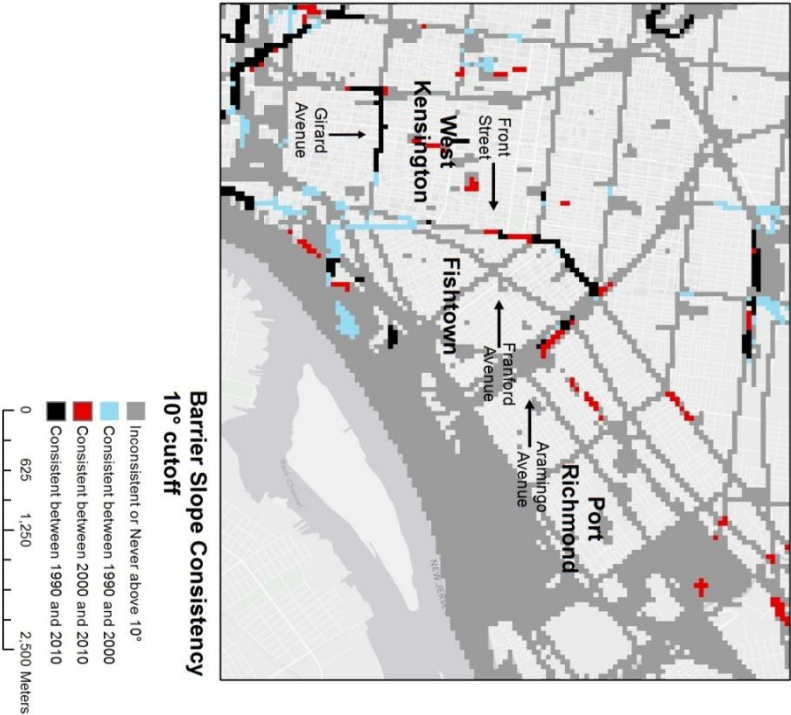
The final map of black/non-black racial slopes clarifies the isolation of the black population in North Philadelphia in more depth. Because the Kensington area of Philadelphia has become a large hub of Hispanic immigration, the slopes protecting white neighborhoods like Port Richmond and Fishtown are not divides between black and white but are now divides between white and Hispanic. In the third map, then, none of the barriers discussed earlier are consistent. Instead, the bulk of the slope consistency between black and non-black areas are to the west, particularly defined by SEPTA railroad tracks that isolate black neighborhoods from areas seeing Hispanic immigration and some infusion of capital, and from the neighborhoods around Temple University which have been undergoing substantial improvement due to investment by the university

Figure 5.4. Maps of Racial Slopes, Fishtown, Port Richmond, and Kensington Neighborhoods, 1000 meter neighborhood radius

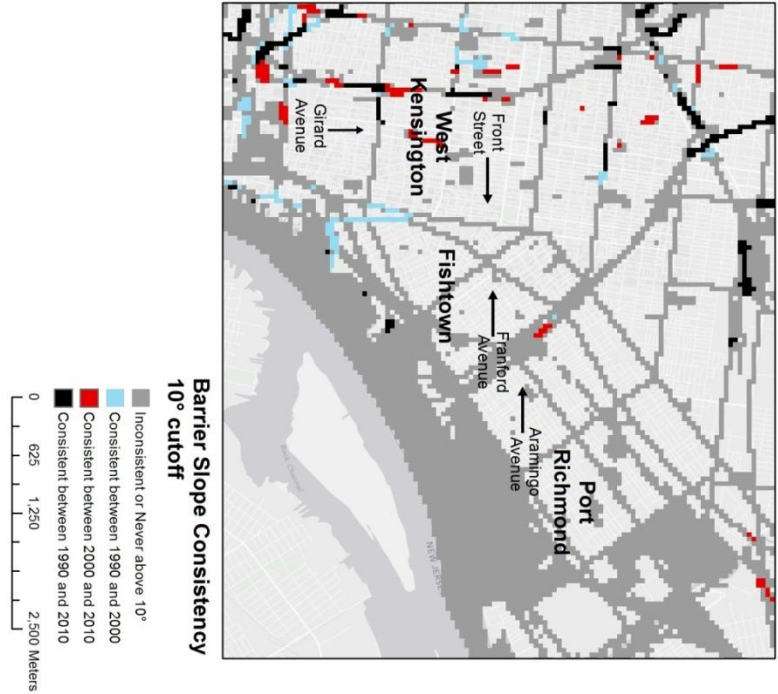
White/Non-White Slopes



Black/White Slope



Black/Non-Black



into its surrounding environments. The black population in that section of North Philadelphia is missing on the redevelopment of North Philadelphia in two directions. To the west, the railroad tracks divide it from the reinvestment spurred by Temple; while the gentrification of Fishtown may eventually spread west into Kensington, that area is now primarily Hispanic.

Consistency Across Barriers?

The overwhelming majority of barriers are never associated at all with racial change, even when assigned extremely high friction. Further, within the minority of barriers that do have high racial slopes, only a minority consistently have high racial slopes in two or more decennial census years. That said, the closer study of three areas of the city show that those few consistent barriers can help identify locations to explore in more depths to understand how and why only some barriers can be multi-generational racial boundaries. The three main case studies identified above are the roads that isolate Chestnut Hill and the growing impact of the railroad tracks that splits West Mount Airy; the section of South Broad between Point Breeze and South Philadelphia; and the combination of Front Street, Frankford Avenue, and Aramingo Avenue that separate Port Richmond and Fishtown from Kensington.

The first separation discussed, that of Chestnut Hill and West Mount Airy from East Mount Airy and West Oak Lane, is strongly related to class status. Chestnut Hill has long been home to some of Philadelphia's wealthiest families, and it is unsurprising to

see that wealth is associated with a sharp racial divide. Similarly, the railroad tracks in West Mount Airy also bisect it into a wealthier, white section of large, single family lots to the tracks' west and a majority black section of row homes to the east. In both cases, class is strongly associated with the racial divides. "The other side of the tracks" is a story of race and class inequality. Structurally, this is expected; in areas where two groups with very disparate wealth statuses exist near each other, the wealthier group's advantages allow it to self-segregate. As income inequality and segregation has grown over time, West Mount Airy has grown both economically and racially more segregated like the rest of society (Reardon and Bischoff 2011). In northwest Philadelphia, race and class are bounded together.

The other two examples, however, show that large class differentiations are not the requisite explanation of racial boundaries. Fishtown, until only recently, has been one of the few remaining bastions of white urban poverty in the United States—so famously identified as such that Charles Murray used the name for his ideal type white working class/poor neighborhood in his most recent book, ironically just after Fishtown began to be gentrified (Murray 2012). Similarly, while South Philadelphia has seen much more gentrification and reinvestment in the past 10 years than Fishtown and Port Richmond, in 1990 and 2000 it was a largely neglected neighborhood that was on the cusp of being revitalized by white gentrifiers and Asian and Hispanic immigration. In other words, while West Mount Airy and Chestnut Hill are an example of areas in which wealth and race were inextricably associated with each other, that association does not exist in either of the other sections of Philadelphia mapped in this section.

Al Hunter's work on symbolic communities and boundaries points to a potential explanation for why certain barriers are consistent racial boundaries. Hunter argues that physical barriers made it easier for residents of Chicago to identify the boundaries of their smaller community. As Hunter notes "Boundaries are significant not only for identification but for social action..." (1982; 68) Those areas without clear physical boundaries may also lack the social cohesion and identity to create behavioral differences or symbolic meanings to specific roads. In sum, the historical specificity of the ethnic identities associated with Fishtown, Port Richmond, and South Philadelphia may help explain why those areas instead of other traditionally white neighborhoods of Philadelphia have avoided experiencing racial turnover. The symbolic ethnicity of the immigrant groups in those neighborhoods may be associated with the continued segregation there and the history of racial violence in those neighborhoods in the 1970s that lingers today (Suttles 1972; Waters 1990; Hirsch 1998). The geographic structure of the city and its barriers coalesced with the cultural geography to create zones of exclusion that have persisted for decades while the rest of the city has undergone dramatic turnover. The causal order cannot be determined here without exploring the history of Philadelphia's spaces in more depth, but regardless of the causal order, it is clear that culturally significant barriers that are also physical structures are also the racially significant ones. Physical structure and local history have combined to create a micro-segregation within the city that warrants further attention and research to understand how structure and culture interact and multiply their impacts on racial residential segregation, and how those interactions may or may not be mitigated through

urban policy and/or new physical structures to minimize the bounding impact of specific structural and cultural barriers in the city.

Conclusion

Racial residential segregation can be thought of as having two key geographic components. There are the neighborhoods in which each racial group is either over or under-represented and there are the boundaries between those neighborhoods. Due to methodological limitations, the empirical research on segregation has focused on the neighborhoods but not the boundaries, even though sociologists have recognized the importance of the boundary for shaping segregation outcomes (Hunter 1982; Park 1925). This chapter is the first large scale empirical study of segregation that studies the boundary instead of the neighborhood.

First, I demonstrate that the uses of different geographical spaces are related to the local changes in racial demographics. To do so, I use the kernel density approach first used by Reardon and colleagues (2008) and then measure the rate of change across different land uses—residential spaces, nonresidential spaces, waterways, major roads, and railroad tracks—in Philadelphia. By comparing the rate of change at nonresidential spaces to the Philadelphia average, I show that land uses such as roads, railroads, and nonresidential spaces (e.g. fully commercial blocks, industrial areas, vacant blocks, large schools) are associated with steeper racial slopes. The geography of the city directly impacts the geography of segregation.

Having shown that these land uses are associated with steeper racial slopes in Philadelphia, I next study the frequency of extremely steep slopes at such land uses or barriers. In this section of the chapter, I incorporate the non-euclidean kernel density analysis first introduced in the previous chapter. Using a realistic size of an average neighborhood (1000 meter radii) and the highest friction setting, I explore which barriers are uniquely associated with racial change across space. This analysis is done in two steps. First, I show that only a small, but substantial, subsection of all of the potential racial boundaries in Philadelphia actually are racial boundaries. Most barriers lie between two areas with identical or nearly identical racial compositions. Where they are racial boundaries, barriers are most likely to surround white residents; physical geography and land use is most associated with whites isolating themselves from other residents rather than as a way to isolate black residents or immigrants. Second, by mapping those few consistently high slope barriers, I identify three subsections of Philadelphia that are uniquely consistently segregated at barriers. By identifying these areas, I could hypothesize about why specific barriers or neighborhoods were consistent racial boundaries. While two cases (West Mount Airy and Chestnut Hill) appear to use barriers as a form of racial and class bounding, the South Philadelphia and Fishtown, Port Richmond, and Kensington case studies did not have the same class differentiation as in Chestnut Hill and West Mount Airy. However, those areas of Philadelphia were the hubs of white working class ethnic immigration in the early 20th century and have continued to have strong symbolic ethnic identities. As such, along with Chestnut Hill and West Mount Airy, those neighborhoods are some of the few areas of Philadelphia with specific

ethnic or class identities for their white residents. In this case, the structural advantages of having easily identifiable barriers at the edges of a community and the ability to create a cultural narrative of a unique subcultural identity may be at the center of the perpetuation of these areas' history of black exclusion. Importantly, without a larger historical or qualitative study, it is impossible to show that these cultural forms were activated in particular to resist efforts at integration. However, the history of racial violence in both sections of Philadelphia during the 1950s and 1960s (see Countryman 2005) indicate that those acts of violence and the specific white identities that helped spur those acts of violence continue to impact Philadelphia's landscape a full decade into the 21st century. Future research should focus on those specific barriers identified here and construct an empirically based theory of how specific streets or railroad tracks become persistent racial boundaries.

While this chapter presents a novel form of quantitative analysis of racial residential segregation, it does not come without limitations. First, the census definitions of major roads may be inaccurate or may miss roads with important local meanings. For example, Washington Avenue is a four lane road that is commonly seen as a dividing line between neighborhoods by Philadelphians. However, according to TIGER data, Washington Avenue is a tertiary street. Had Washington Avenue been identified as a major road like other roads of its size such as Girard or Germantown Avenues, the black neighborhood of Point Breeze would have had steep barriers in all four directions. This chapter treats all possible barriers as equally difficult to cross (unless they are of unequal widths), even though the analysis shows that not all major roads or railroad tracks are

equally important racial boundaries. Finally, many barriers are located near each other; for example, major roads lie on both sides of the Schuylkill River and thus may lower the average “impact” of barriers on racial slopes incorrectly. In that case, the roads would be the racial boundaries, even though it is the existence of the river that caused the roads to be built there and that actually divides the neighborhoods on the river banks from each other.

Nonetheless, the chapter’s finding that barriers have significant associations with the local patterns of racial segregation and turnover helps answer why segregation continues to be so entrenched in most major cities. Policy makers can use this analysis to identify areas in which racial boundaries are uniquely persistent or uniquely new to craft local policies to encourage development or improve pedestrian access across barriers to help spur integration or avoid experiencing complete racial turnover. Future research can also use this focus on boundaries to explore other local patterns that can have dramatic effects on racial equality, such as crime patterns, access to healthy foods or recreational spaces, and housing and commercial price and investment patterns. It is time for research to study segregation not only as a problem of census tracts and neighborhoods, but also as a problem of boundaries.

Chapter 6:

Space and Segregation:

A Case for a Spatial and Visual Sociology of Inequality

According to cliché, real estate is all about “location, location, location!” If that extends beyond real estate valuations, then a spatial turn in the social sciences is long past due. Fortunately, a growing sociology of neighborhood and contextual effects has begun to reconsider the role of spatial context on individual outcomes from education to health to crime victimization (Sampson 2012; Peterson and Krivo 2010; Morenoff and Lynch 2004). Unfortunately, while sociologists now study how spatial context impacts individual outcomes, they have not yet reconsidered how it defines social space. Bringing space into sociology can and should be a more revolutionary advance than adjusting a regression to include nearby census tracts in the analysis or determining how to sample a city’s blocks to create a measure of local disorder (Raudenbush and Sampson 1999). Similarly, efforts to theorize about space and its impact by some sociologist such as Gans (2002) and Neely and Samura (2011) have not connected those insights into the impact of space on social processes to empirical research questions. In the first case, space is treated as another variable to be added to the traditional variables of sociology without requiring substantial reconsiderations of basic sociological assumptions about how race and inequality operate via the creating and policing of racialized social spaces. In the second, the desire to recast sociology as a spatial and social science overwhelms the efforts and does not illuminate how to go about doing so as part of a research agenda. For

example, theorists assert that “the characteristics of racial space help illuminate social processes that would otherwise remain less visible” (Neely and Samura 2011: 1947) without identifying how a spatial analysis would do so, or even would do so differently from traditional sociological methods. One is either too grounded in sociology’s history of aspatial analysis or so removed from that empiricism as to proffer questions without considering whether or not there are sociological means for answering.

This dissertation provides a third option, one which builds on sociology’s rich history of studying racial inequality but does so through an explicitly spatial orientation. Each of the three empirical chapters is a unique example of how to integrate space into the sociology of segregation. In addition, a more spatial sociology can be a more visual and more public sociology that could have a more direct impact on public policy and opinion. If a picture is worth one thousand words, how many is a map worth? Chapter two answers that question: a full decade. Results from traditional analyses of segregation in Philadelphia between 1990 and 2010 show that neighborhoods that appear integrated during a specific census are actually in the midst of racial turnover and were measured during that transition. Integration is an unstable racial composition for neighborhoods in Philadelphia, save for two exceptions—West Mount Airy and University City—which stayed integrated for at least two decennial censuses in a row. Unfortunately, that interpretation is only valid if one does not map the racial composition of those neighborhoods. Using a very simple raster mapping technique first introduced to sociology generally by Downey (2006) and specifically to the study of residential segregation by Lee and colleagues (2008), maps of West Mount Airy and University City

show growing segregation during the 2000 census, though traditional indices of segregation indicated that both neighborhoods were integrated in 2000. In sum, chapter two proves that a spatial and visual approach to studies of racial segregation can not only augment the presentation of findings into a more provocative and accessible means, but also challenge the basic findings that come from traditional, aspatial methods.

Chapter three offers a methodological enhancement to sociological measures of segregation that originates from theories of social space and social boundaries (Lee et al. 2008; Reardon et al. 2009). Previous research introduced surface density analytic techniques to the study of racial segregation. In the process, they made a critical first step linking the substantive interests of sociologists to spatial analysis. However, those spatial techniques were created for non-social spatial questions, such as mining exploration and water-flow patterns. As such, space could be treated as a relatively continuous: the vector or direction did not matter in standard kernel density smoothing estimates. When Lee and colleagues (2008) introduced the method, they noted that it lacked a consideration of how residential social space is not continuous: physical attributes of the space are not equal. In other words, living 100 meters away from someone of a different race who lives a block away across a small one way road is qualitatively different from living 100 feet away from that same person, but across a highway or a block full of vacant houses. The characteristics of a space change its social uses, as Hunter (1982), Jacobs (1961), and even Park (1925) theorize. Unfortunately, until now those differences in social relations across different types of social spaces had not been incorporated into the study of racial segregation. In chapter three, I incorporate land use, as well as the location of major

roads, railroads, and rivers to enhance the spatial measurement of racial residential segregation.

Fortunately for the large body of empirical research on segregation, there were few major differences in the city-level results: Philadelphia continues to be hypersegregated, and the only major change at the city level is that the size of one's "egocentric neighborhood" no longer relates to the level of black-white segregation in Philadelphia. The Philadelphia case study calls into question the finding that there were variations in the relationship between macro and micro-levels of segregation across cities. It may instead be that these micro- and macro- differences (or, differences in a city's "segregation profile" in Reardon and colleague's terminology) were due to differences in each city's geography. Cities with more major roads and railroads might have had greater changes in Reardon and colleague's work because the bounding of racial groups caused by those aspects of a city's landscape were not included in their analysis.

Philadelphia may have been a poor case study for studying the impact of barriers on racial segregation patterns. Philadelphia is hypersegregated and that hypersegregation is and has been very stable. Barriers may not have had substantial impacts on Philadelphia's dissimilarity index in part because there was little room for Philadelphia appear be more segregated than traditional measures already report. Newer cities or cities with a less entrenched black/white divide may see more of an effect of barriers on segregation as more residents would be moving in from elsewhere and might use major roads or railroads as part of their decision on where to reside. Cities with less extensive

public transportation options may rely more on large, major roads and highways that could then also be reinforced as stronger racial barriers. Future research should compare multiple cities to test whether or not there are differences across cities that might explain why barriers are or are not important to citywide metrics of segregation for different locations.

More importantly, incorporating barriers into the kernel density smoothing changes the local patterns of segregation. Without barriers, maps of Philadelphia showed concentrations of black residents that spread and grew diffuse over space. Once the barriers are incorporated into the analysis, black residents instead appear strongly bounded and constrained by barriers, either being almost completely absent from neighborhoods or highly concentrated in them. Maps of the changes in entropy (a measure of spatial segregation) also highlight the significant local impact of barriers, including major roads, rivers, and railroad tracks. While the city level impact of barriers is relatively muted, maps of *where* barriers impact levels of segregation provided valuable insight into the city's racial geography. Where the traditional kernel density maps show that North and West Philadelphia have large black populations, it also appears as though those populations spread throughout those large sections of Philadelphia. In reality, the black population is hemmed in by specific barriers and similar boundaries exist for both Hispanic and Asian residents as well. The maps in this chapter provide a more granular level of analysis that can help researchers provide more accurate insights into the racial geography of a city. In addition, the maps that can be created with the improved method offer policymakers and local agents opportunities to more directly

focus efforts to create inter-neighborhood interactions that are also interracial in nature or to remove barriers to interaction that would spur greater integration, instead of focusing similar efforts on barriers that do not serve as racial boundaries. In this chapter, classic sociological insights into how space operates to create communities and neighborhoods identified a flaw in previous efforts to incorporate spatial analysis that is surmounted via a novel correction to traditional kernel density methods.

Chapter 5 is the most unique chapter compared to traditional sociological studies of racial residential segregation. Instead of studying the communities in which people reside or the overall levels of segregation in the city, this chapter is the first empirical study of racial boundaries themselves and is not possible without merging spatial analysis and sociological research interests. The chapter first tests whether or not barriers are related to locations of racial demographic change in the city and shows that even without giving barriers higher friction in the smoothing analysis, barriers such as railroad tracks and nonresidential blocks have much higher racial rates of change (racial slopes) than residential land. Having shown that barriers are associated with higher racial slopes, I test whether or not those associations are consistent over time. In this part of the analysis, it became clear that not only are most barriers not racial boundaries between groups but also that most of the barriers that are racial boundaries at one time period are no longer boundaries ten years later. In general, while a number of barriers are racial boundaries at a given time, the majority of those boundaries topple over time and only a small fraction of the barriers are persistent racial boundaries.

The next question is where racial boundaries are persistent and what might explain those consistencies? Here, a visual sociology is particularly valuable as mapping the location of the consistent racial boundaries identifies exactly where those boundaries are and how large they are. The analysis then studies three areas throughout the city in depth to explore the specific racial and ethnic barriers that occur in those spaces and hypothesizes about why specific barriers are consistent across generations. The section of northwest Philadelphia with persistent racial boundaries indicates that race and class might be intertwined and that class helps explain the consistency of the barrier between East Mount Airy and Chestnut Hill and the growth of a barrier within West Mount Airy. However, the case studies of South Philadelphia and Fishtown, Kensington and Port Richmond refute that hypothesis. In those cases, the white areas, although currently undergoing gentrification, are either high poverty areas themselves or bastions of white immigration. Class, then, is not a required factor for the creation of persistent racial boundaries. The areas surrounded by persistent racial boundaries do share a unique component: each is identifiable not only as a white neighborhood, but more specifically as a nexus of unique and easily identified white sub-populations. West Mount Airy, Chestnut Hill, Fishtown and Port Richmond, and South Philadelphia are areas with specific white ethnic or class identities, as opposed to other previously white areas that did undergo racial transitions, such as the lower northeast, parts of Fairmount, and sections of West Philadelphia. This leads back to the symbolic community theory of Al Hunter (1982) that argues that spaces are more likely to have social impacts on residents and visitors when specific roads or boundaries can be easily identified. Hunter notes that

the symbolic nature of “crossing the tracks” can lead to behavioral changes—but not all tracks have that effect. Similarly, the ability to identify specific boundaries as the edge of a specific white population’s neighborhood may have led to greater efforts to protect those boundaries from racial turnover, in a perverse twist on collective efficacy, it may be that those white neighborhoods with greater collective efficacy and identifiable boundaries were those who could defend their segregation in the face of potential racial change (e.g Hirsch 1998). Some circumstantial evidence of greater incidences of racial violence during the 1960s and 1970s in those areas, specifically violent acts by whites in both South Philadelphia and Port Richmond in the face of encroaching black populations exists (Countryman 2005). However, the causal order is unclear: did these areas have a sharp racial boundary created for them by structural forces such as bank lending policies like redlining and the construction of highways and railroad tracks in between communities or did those physical structures get built or expanded in specific locations because those locations were already entrenched racial boundaries? Further archival or qualitative work should explore how those specific barriers in Philadelphia came to become deeply entrenched boundaries as opposed to other possible boundaries and whether or not the strong ethnic identifications in those areas played a role in imbuing racial significance to major roads and railroad tracks.

Social space is a unique form of space and a unique component of sociality. How humans manipulate and transform space can make it safer or less safe, foreboding or welcoming, grandiose or garish, racially inclusive or racially exclusive. How we use space helps explain how we organize ourselves into those spaces and how those spaces

impact how we act. One of the ongoing frustrations for scholars and activists who work to expose the inequalities and injustices of society is that racial and socioeconomic inequality often is rendered invisible because of how easily privileged Americans isolate themselves. Large cities and the racial and class diversity in them are the main locations where those invisible problems can potentially become more visible to more Americans. Racial boundaries, however, allow that invisibility to persist even when racially diverse groups live near each other. By identifying where those boundaries are, how persistent they are, and what they mean for the level and patterns of racial segregation in a city, this research offers a new lens through which policy makers and researchers can expose those inequalities, hopefully to larger audiences.

For example, Philadelphia is currently investing in improvements to commercial corridors outside of the center city. North Broad Street, Girard Avenue, and Spring Garden have been targeted recently for intervention by city government including commercial redevelopment (North Broad between Spring Garden and Girard), improved infrastructure (East Girard), and beautification and increased pedestrian and cyclist access (Spring Garden). All three are valuable potential improvements. However, only North Broad Street doubles as a persistent racial boundary between a wealthier, whiter neighborhood and a poorer black neighborhood. How the redevelopment of North Broad Street occurs may dissolve that racial boundary depending on whether or not the road becomes a zone of interracial interaction by opening businesses catering to a variety of groups. If, on the other hand, that redevelopment focuses on bringing only high-end luxury commerce or only less expensive commerce to the area, it may intensify the racial

boundary's impact. On the other hand, the section of East Girard Avenue undergoing repaving is largely contained within a white neighborhood. Perhaps focusing on improving the infrastructure, pedestrian access, and commercial options on sections of Aramingo or of Kensington Avenue that are racial boundaries and are parallel arterial roads to Girard might help dissolve the persistent racial boundaries at those roads. In short, identifying racial boundaries can help better identify where policy makers and governments should focus efforts to decrease segregation and build more consistently diverse communities instead of perpetuate the cycle of racial turnover neighborhood by neighborhood.

While this project has opened up new avenues for studying and presenting racial segregation by more aggressively using spatial thinking and analysis to guide the project, it is only a first step in that direction. A number of limitations remain and future research should look to resolve them. First, while the project avoids using *a priori* proxies of neighborhoods, it relies on *a priori* definitions of potential racial boundaries. Railroad tracks, highways and major roads, and nonresidential blocks are likely locations of neighborhood boundaries, but more possibilities exist. Parks, for example, can both be a potential neighborhood hub (such as Rittenhouse Park) or located at the divide two neighborhoods from each other (Wissahickon Park, or, to move outside of Philadelphia, Prospect Park in Brooklyn). Similarly, some major roads and nonresidential blocks may be commercial corridors in which locals congregate and bind neighbors together into a community, or may be corridors in which industrial or large office buildings create dead zones at night that might impede interaction and/or desegregation. Finally, defining major

roads is a challenge: while the census bureau offers a definition for the entire country, some of those roads may be relatively small and easily crossable but receive state funding (and thus possibly deemed “secondary”), while some roads may be listed as tertiary even though they are four lanes wide and seen as boundaries by local residents (Washington Avenue in South Philadelphia, for example). Further, Grannis’ t-communities (1998; 2009) are not only bounded by major roads, but also did not have tertiary roads that crossed those major roads. While this project shows that such a definition is perhaps overly limited (many of the persistent racial boundaries, such as Broad Street, had many tertiary roads crossing them and would not have been identified as boundaries between t-communities by Grannis), Grannis’ insight that the street network as well as the size of roads impacted the racial organization of a city is worth further exploration.

Even were the barriers perfectly identified, another methodological concern is how much those barriers should affect the smoothing function. That is—are barriers walls between neighborhoods, or could barriers be the equivalent of a speed bump on a road? To resolve that concern in this dissertation, I examined multiple different friction levels at barriers to test whether or not changing the impact of barriers on the smoothing function would change the substantive results. In general, once barriers were assigned greater than double the friction of residential areas (either the 10x or 1000x level), the results were similar. However, it may be that some barriers are only slight speed bumps for residential community building while others are effectively walls. For example, an elevated highway is likely a divide between two neighborhoods while a secondary street that is only 2 or 4 lanes should have a smaller effect on the smoothing function. More micro-level analysis

of how geographic features of the city affect residential patterns may help lead to a theory of neighborhood boundaries that could inform analysis such as those in this dissertation.

A related question that remains unanswered is how to define the size of a neighborhood. Imagine a completely flat space with no major roads, railroads, or other potential barriers. How far in each direction should one's "neighborhood" extend? To date, researchers studying neighborhoods have used 500 meters and 1000 meters as two potential neighborhood sizes based on estimates of walkable distances for typical residents. However, those sizes have not been confirmed by surveys of residents, who often differ greatly on the size of their neighborhood (Guest and Lee 1984), or via careful analyses of neighborhoods that have universally identified boundaries. In addition, neighborhood size may be related to city size and type: neighborhoods in New York City are often larger in size than in smaller cities, while suburban neighborhoods may be particularly small or large depending on the layout of that particular suburb's housing. In sum, by no longer needing to use *a priori* definitions of neighborhoods, a number of questions about the size, shape, and bounding of neighborhoods come to light. Until now, those questions had largely gone unconsidered and unanswered because sociologists relied on the census tract as the best proxy for a neighborhood. Now that sociological research is no longer constrained by those proxies, basic definitional questions of the neighborhood that have been neglected are now considerably more important to resolve both theoretically and methodologically.

The project also identified a methodological flaw in the entropy index as a measure of evenness that points toward an improvement on the measurement. The entropy index is non-linear and that non-linearity is highly unstable when comparing a continuous population to a discontinuous population. In other words, including barriers in the analysis of a city's segregation levels had unexpected and potentially misleading effects on the city's entropy index (particularly its multigroup entropy score) compared to simulations without barriers. Dissimilarity, as a linear measure of evenness, did not experience the same instability. In the future, a standardized entropy index could resolve that instability and also enhance the accuracy of the multigroup entropy index more broadly.

Spatial racial inequality is a common area of study within sociology and is central to many of the best theories of racial inequality's persistence and impact on individuals. From classics like Du Bois' *Philadelphia Negro* (1996 [1899]) and Massey and Denton's *American Apartheid* (1993) and more recent work (e.g. Charles 2006; Peterson and Krivo 2010; Sampson 2012), the spatial component of racial inequality has been critical to understanding how structure creates and perpetuates inequality while also hiding it behind an elevated subway track or across a highway. This dissertation highlights the added benefits of spatial analysis to the study of the racial-spatial divide. It is time for sociologists to interrogate the contestation over social space as a question of inequality and also as a question of how social spaces are created, imagined, and reified. A spatial sociology of inequality would study how persistent racial boundaries are or are not

associated with changes in housing stocks, crime patterns, school attendance boundaries, or public health outcomes.

A spatial sociology of inequality provides a new arena to study and theorize about how structure and culture create inequality. Understanding how and why specific locations act as either strong or weak racial boundaries—and whether or not those boundaries are persistent—provides a new lens for understanding how forms of inequality are created via architecture, governmental spending, and cultural understandings of territory. Spatial thinking helped explain why census tracts are poor proxies for neighborhoods, how to resolve that problem via kernel density smoothing, and how that smoothing would be enhanced by including a variable friction to the smoothing function. This dissertation project shows how a spatial sociology not only can provide new methodologies for studying inequality but also provides entirely new avenues of study. In this dissertation, I present the existence and persistence of racial boundaries as a new frame through which to understand segregation. Of course, spatial analysis is not limited to just studying boundaries. Within the study of racial inequality and policing, for example, a spatial examination of crime patterns could show whether or not crime is differently patrolled by the police in different parts of a city or whether or not crime spills over across barriers from one neighborhood to another differently depending on the racial compositions of those neighborhoods. Similarly, a spatial sociology might interrogate how transportation systems and access to public transportation can impact the location of redevelopment, gentrification, and racial turnover. A spatial sociology can explore what specific components of inequality and

geography account for where neighborhood boundaries exist, which neighborhood boundaries persist, and which boundaries perpetuate or weaken racial inequality.

Spatial sociology also can be a more public sociology. Maps and other visual presentations of data are often more accessible to non-experts. Sociological research has grown more and more advanced and analytic techniques more varied and complex. In the 1980s, Massey and Denton identified 5 dimensions of segregation and multiple potential measures of each dimension. Since then, even more metrics have been introduced, compared, and used in the literature while the total number of dimensions of segregation has also been examined and challenged (e.g. Brown and Chung 2006; Reardon and O'Sullivan 2004). Sociological studies of segregation are occasionally cited in the press and experts are often asked for quotes, but no recent sociological study of segregation gained as much attention after the 2010 census as a series of maps made by an amateur cartographer. Visualizing data on a map is not only appealing to read and more easily shared with others, but it requires the researcher to focus the presentation on only a few components of an analysis. Du Bois realized he should begin his study of racial inequality in Philadelphia with a map; over 100 years later, it is well past time for other sociologists to follow his lead.

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